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KLY- 4 / KLY- 4S / CS- 3 / CS- L

User's Guide

Modular system for measuring magnetic susceptibility,
anisotropy of magnetic susceptibility,
and temperature variation of magnetic susceptibility.

AGICO
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Brno
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Introduction to the User's Guide

Thank you for purchasing magnetic susceptibility meter AGICO Kappabridge KLY-4.

Kappabridge and its optional accessories represent modular system designed for measurement of magnetic susceptibility of rock and its anisotropy in variable fields, and in conjunction with furnace or cryostat apparatus, also for measurement of temperature variation of magnetic susceptibility.

Preface

The User's Guide is divided into two parts.

- The Part 1, **Kappabridge KLY-4 / KLY-4S**, contains general common information, description and specifications of individual modules, and decribes the capabilities of the system. The attention is focused on measurement of anisotropy of magnetic susceptibility (AMS) using the Kappabridge KLY-4S with a spinning specimen and the KLY-4 version with static specimen.

- The Part 2, Apparatus **CS-3 / CS-L**, describes the measurement of temperature variation of magnetic susceptibility using the high temperature furnace CS-3 and low temperature cryostat CS-L.

KAPPABRIDGE
KLY- 4 / KLY- 4S

User's Manual

Instrument for measuring magnetic susceptibility
and its anisotropy in variable fields

AGICO
Advanced Geoscience Instruments Co.
Brno
Czech Republic

Warranty

AGICO warrants that this product will be free from defects in materials and workmanship for a period of 1 (one) year from date of installation. However, if the installation is performed later than 3 (three) months after the date of shipment due to causes on side of Customer, the warranty period begins three months after the date of shipment. If any such product proves defective during this warranty period, AGICO, at its option, either will repair the defective product without charge for parts and labour, or will provide a replacement in exchange for the defective product.

In order to obtain service under this warranty, Customer must notify AGICO of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. AGICO will decide if the repair is to be performed by AGICO technician or AGICO delegated serviceman in customers laboratory, or product shall be sent for repair to the manufacturer. In latter case, customer shall be responsible for packaging and shipping the defective product to the AGICO service centre. In both cases, all the costs related to a warranty repair shall be at expenses of AGICO.

The warranty becomes invalid if the Customer modifies the instrument or fails to follow the operating instructions, in case of failure caused by improper use or improper or inadequate maintenance and care, or if the Customer attempts to install the instrument without explicit written permission of AGICO company. AGICO shall not be obligated to furnish service under this warranty a) to repair damage resulting from attempts by personnel other than AGICO representatives to install, repair or service the product; b) to repair damage resulting from improper use or connection to incompatible equipment; or c) to service a product that has been modified or integrated with other products when the effect of such modification increases the time or difficulty of servicing the product.

This warranty is given by AGICO with respect to this product in lieu of any other warranties, expressed or implied. AGICO and its vendors disclaim any implied warranties of merchantability or fitness for a particular purpose. AGICO’s responsibility to repair or replace defective products is the sole and exclusive remedy provided to the Customer for breach of this warranty. AGICO and its vendors will not be liable for any indirect, special, incidental, or consequential damages irrespective of whether AGICO or vendor has advance notice of the possibility of such damages.

General Safety Summary

Review the following safety precautions to avoid and prevent damage to this product or any products connected to it.

Only qualified personnel should perform service procedures.

Convention

Symbol **Attention** is used to draw attention to a particular information.

Symbol **Prohibition** is used to accent important instruction, omission of which may cause lost of properties, damage or injury.

Injury Precautions

Use Proper Power Cord. To avoid fire hazard, use only the power cord specified for this product.

Do Not Operate Without Covers. To avoid electric shock or fire hazard, do not operate this product with covers or panels removed.

Fasten Connectors. Do not operate the instrument if all connectors are not properly plugged and fixed by screws.

Do Not Operate in Wet / Damp Conditions. To avoid electric shock, do not operate this product in wet or damp conditions.

Do Not Operate in an Explosive Atmosphere. To avoid injury or fire hazard, do not operate this product in an explosive atmosphere.

Disconnect Power Source. To avoid risk of electric shock unplug the instrument from mains before reinstalling or removing unit.

Product Damage Precautions

Use Proper Power Source. Do not operate this product from a power source that applies more than the voltage specified.

Use Proper Fuses only. Do not use fuses which are not specified by the manufacturer. If a fuse with a different characteristics or value is used, the protection is not effective.

Operator's Training. Operator should be familiar with operation of the instrument and Safety Regulations.

Use Manufacturer's Cables Only. Other devices can be connected to the instrument via the appropriate cables only.

Do Not Disconnect Connectors. To avoid damage of the instrument never disconnect any connector while device is on.

Do Not Operate With Suspected Failures. If you suspect there is damage to this product, have it inspected by qualified service personnel.

Getting Started

In addition to a brief product description, this chapter covers the following topics:

- ❒ Specifications of Individual Modules.
- ❒ Declaration of Conformity.
- ❒ Unpacking Instructions.
- ❒ Storage and Transportation.

KLY-4S / KLY-4 Description

The **KLY-4S / KLY-4 Kappabridge** is probably the world's most sensitive commercially available laboratory instrument for measuring bulk magnetic susceptibility and anisotropy of magnetic susceptibility (AMS). The Kappabridge has the following features:

- High sensitivity.
- Automatic zeroing over the entire measuring range.
- Autoranging.
- Slowly spinning specimen (KLY-4S).
- Quick AMS measurement (KLY-4S).
- Easy manipulation.
- Only three manual manipulations for measuring AMS (KLY-4S).
- Built-in circuitry for controlling the furnace CS-3 and cryostat CS-L.
- Full control by computer.
- Sophisticated software support.

The Kappabridge apparatus consists of the Pick-Up Unit, Control Unit and User's Computer. In principle the instrument represents a precision fully automatic inductivity bridge. It is equipped with automatic zeroing system and automatic compensation of the thermal drift of the bridge unbalance as well as automatic switching appropriate measuring range. The measuring coils are designed as 6th-order compensated solenoids with a remarkably high field homogeneity.

The digital part of the instrument is based on micro-electronic components, with the microprocessor controlling all functions of the Kappabridge. The instrument has no control knobs, it is fully controlled by external computer via serial channel RS-232C.

The **KLY-4** version measures the AMS of a static specimen fixed in the manual holder. In the static method, the same as in KLY-2 or KLY-3 bridges, the specimen susceptibility is measured in 15 different orientations following rotatable design. From these values six independent components of the susceptibility tensor and statistical errors of its determination are calculated using software **SUFAM**. The specimen positions are changed manually during measurement.

The **KLY-4S** version measures the AMS of a spinning specimen fixed in the rotator. In the spinning method, the specimen rotates with small speed of 0.5 r.p.s. inside the coil, subsequently about three axes. From these data, the deviatoric susceptibility tensor can be computed. This tensor carries information only on anisotropic component of the specimens. For obtaining complete susceptibility tensor one complementary measurement of bulk susceptibility must be done.

The main advantage of the new model KLY-4 / KLY-4S is a possibility to measure bulk susceptibility and AMS in variable fields from 3A/m to 450 A/m in 21 steps. The autoranging and autozeroing work over the entire measuring range. Automatic zeroing compensates real and imaginary components, the zeroing circuits work in digital way using 16-bit up-down counters and D/A converters. The output signal is digitalized, raw data are transferred directly to the computer which controls all the instrument functions. These features enable to zero the bridge prior the anisotropy measurement after inserting the specimen into the measuring coil. The ´background´ bulk susceptibility is eliminated and the bridge measures only the susceptibility changes during specimen rotation and thus the most sensitive range can be used. The result is high precision of measurement and determination of principlal directions of susceptibility tensor.

One has to adjust the specimen only in three perpendicular positions. Thus the specimen measurement time was dramatically shortened. The measurement is rapid, about two minutes per specimen, and precise, profiting from many susceptibility determinations in each plane perpendicular to the axis of specimen rotation. The static method of the measurement can also be used.

Software **SUFAR** combines the measurements in three perpendicular planes plus one bulk value to create a complete susceptibility tensor. The errors in determination of this tensor are estimated using a new method based on multivariate statistics principle.

KLY-4S / KLY-4 Specifications

			Spinning Specimen	*Static Specimen*
Specimen Size[1]	Cylinder	Diameter	25.4 mm (+0. 2 , -1. 5)	25.4 mm (+1. 0, -1. 0)
		Length	22.0 mm (+0. 5 , -1. 5)	22.0 mm (+2. 0, -2. 0)
	Cube		20 mm (+0. 5 , -1. 5)	20 mm (+0.5 , -2. 0)
	Cube			23 mm (+0.5 , -2. 0)
	ODP box			26 x 25 x 19.5 mm^3
	Fragments (bulk. susc.)			40 cm^3

Pick-up coil inner diameter		43 mm
Nominal specimen volume		10 cm^3
Operating frequency		875 Hz
Field intensity		3 Am^{-1} to 450 Am^{-1} in 21 steps
Field homogeneity		0.2 %
Measuring range		0 to 0.2 (SI)
Sensitivity (300 Am^{-1})	Bulk measurement	3 x 10^{-8} (SI)
	AMS measurement (spinning specimen)	2 x 10^{-8} (SI)
Accuracy within one range		0.1 %
Accuracy of the range divider		0.3 %
Accuracy of the absolute calibration		3 %
HF Electromagnetic Field Intensity Resistance		1 Vm^{-1}
Power requirements		240, 230, 120, 100 V ±10 % 50 / 60 Hz
Power consumption		45 VA
Operating temperature range		+ 15 to + 35 ^oC
Relative humidity		max. 80 %
Dimensions / Mass		
	Measuring Unit	260 mm x 160 mm x 250 mm / 4 kg
	Pick-up Unit	240 mm x 320 mm x 330 mm / 11 kg
	Rotator	320 mm x 70 mm x 65 mm / 1 kg

[1] Holders for specimens of slightly different size can be supplied on request.

CS-3 / CS-L Description

The **CS-3 Temperature Control Unit** has been designed for measurement, in connection with the KLY-4S Kappabridge, of the temperature variation of low-field magnetic susceptibility of minerals, rocks and synthetic materials in the temperature range from ambient temperature to 700 ^{o}C. The apparatus consists of non-magnetic Furnace with a special platinum Thermometer, electronic Temperature Control Unit, cooling water Reservoir with Pump, and Argon Flow Meter. The specimen is placed in a measuring vessel which is heated by a platinum wire in three selectable heating rates. The temperature is measured by special platinum thermometer. The protect Argon atmosphere during heating can be applied to prevent oxidation of measured specimen. To perform susceptibility measurement at a chosen temperature range, the equipment moves automatically the furnace into and out of the pick-up coil of the KLY-4S Kappabridge. The quasi-continuous measurement process is fully automated, being controlled by the software **SUFTE.**

The **CS-L Low Temperature Apparatus** has been designed for measurement, in connection with the KLY-4S Kappabridge and CS-3 Temperature Control Unit, of the temperature variation of low-field magnetic susceptibility of minerals, rocks and synthetic materials in the temperature range from minus 192 ^{o}C to ambient temperature. The apparatus consists of non-magnetic Cryostat with a special platinum Thermometer. The specimen is placed in a measuring vessel which is cooled inside the cryostat by liquid nitrogen and then heated spontaneously to a given temperature. The argon gas is needed for deplenishing the liquid nitrogen out of cryostat. Temperature is measured by special platinum thermometer. The quasi-continuous measurement process, after cooling the specimen, is fully automated, being controlled by the software **SUFTEL.**

CS-3 / CS-L Specifications

Maximum specimen volume (fragments or powder)	0.25 cm^3
Inner diameter of measuring vessel	6.5 mm
Sensitivity to susceptibility changes (300 Am^{-1})	1 x 10^{-7} (SI)
Temperature range CS-3	ambient temperature to 700 ^{o}C
Temperature range CS-L	-192 ^{o}C to ambient temperature
Accuracy of temperature sensor	± 2 ^{o}C
Power requirements	240, 230, 120, 100 V ±10 %, 50 / 60 Hz
Power consumption	350 VA
Dimensions / Mass	
Electronic unit	260 mm x 160 mm x 250 mm / 9 kg
Water container with Pump	380 mm x 380 mm x 700 mm / 2 kg
Argon flow meter	32 mm x 32 mm x 140 mm / 1 kg
Cryostat	diameter 60 mm, length 220 mm / 0.5 kg
Argon gas flow requirement (protect atmosphere)	approx. 100 ml min^{-1}
Amount of liquid nitrogen (cooling cryostat)	approx. 0.5 l for one cooling
Argon gas flow requirement (deplenishing cryostat)	approx. 20 l min^{-1} for about 10 s

EC Declaration of Conformity

We,

AGICO, s.r.o., Ječná 29a, CZ - 621 00 Brno, IČO 607 313 54,

declare that the Modular system for measuring magnetic susceptibility, anisotropy of magnetic susceptibility and temperature variation of magnetic susceptibility,

KLY-4 *indicator of susceptibility and anisotropy of susceptibility,*

KLY-4S *indicator of susceptibility and anisotropy of susceptibility with rotating sample,*

CS-3 *indicator of temperature variation of susceptibility from room temperature to 700 ^{o}C,*

CS-L *indicator of temperature variation of susceptibility from –192 ^{o}C to room temperature,*

meet the intent of directives 89/336 EEC and 73/23 EEC.

The compliance was demonstrated to the following specifications:

ČSN EN 61010-1+A2:1997 (EN 61010-1+A2:1995), ČSN EN 55022:1999 (EN 55022:1998),

ČSN EN 61326-1:1999 (EN 61326-1+A1:1998), ČSN EN 61000-4-2:1997 (EN 61000-4-2:1995),

ČSN EN 61000-4-3:1997 (EN 61000-4-3:1995), ČSN EN 61000-4-4:1997, (EN 61000-4-4:1995),

ČSN EN 61000-4-5:1997 (EN 61000-4-5:1995), ČSN EN 61000-4-6:1997 (EN 61000-4-6:1995),

ČSN EN 61000-4-11:1997 (EN 61000-4-11:1995).

Marking CE: 02

Manufacturer : AGICO, s.r.o., Ječná 29a, CZ - 621 00 Brno.

The judgement of conformity was performed in co-operation with the ITI TÜV s.r.o. Modřanská 98,

CZ – 147 00 Praha 4.

Place and date of issue: Brno, 23 April 2004.

Responsible person: Prof. RNDr. František Hrouda, CSc., director of company.

Unpacking Instructions

Remove carefully the instrument and its accessories from the box and packing material, referring to the packing list included to confirm that everything has been delivered. Briefly inspect each item for shipping damage. If anything is missing or damaged, contact the manufacturer or your dealer immediately. You may want to retain the box and other packing material in case later you need to ship the instrument.

Storage and Transportation

The properly wrapped instrument can be stored and transported at a temperature -20 ^{o}C to + 55 ^{o}C and relative humidity up to 80 %. In both cases the instrument should be stored in suitable premises, free of dust and chemical evaporation.

Installation Procedures

The first installation and training is performed exclusively by the AGICO technician or by the authorised representatives. If you need later to reinstall the apparatus, due to the removing the instrument to another place or any other reasons, be sure the following conditions are met to achieve guaranteed parameters.

Choosing the place

Place the apparatus to a room with relatively magnetically clean environment.

- The instrument must not be placed near sources of alternating magnetic field, e.g. big transformers, electric motors, electricity power source wires, thermal sources etc.

- Do not place the instrument near thermal and electrical sources and prevent the pick-up coils from direct sunshine. The pick-up coils must not be exposed to heat from the sun or from other sources, which would affect the precision of measurement.

- Do not place the pick-up coils near the other instruments or computer's monitors.

- Do not place the instrument to a draughty room. Air condition may sometimes cause higher thermal drift of coils, prevent the direct air flowing in the room .

- The temperature in the room should be stable as much as possible. The temperature variation in the room should not exceed 2 ^{o}C / hour.

- Place the instrument and pick-up unit on a wooden table with good stability which has no iron loop under working desk.

- It is recommended to place the pick-up unit on a separate stand or a small table which should be of such a height so that the middle of the pick-up unit coincides with the level of the working table. This arrangement makes the operation easier.

- During measurement prevent motion of magnetically significant parts (metal parts of chairs, doors, furniture, watches, rings, tools, components of your clothes, etc.)

Interconnection of Units

Fig. 1 shows the Interconnection Scheme. If you are installing only Kappabridge do not care CS-3 unit and its accessories. Be sure the instrument is unplugged from mains during connecting the cables. Fix the connectors by screws, plug the mains socket and switch the Kappabridge on.

Interconnection Scheme KLY-4 / CS-3

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Interconnection Scheme KLY-4 / CS-3

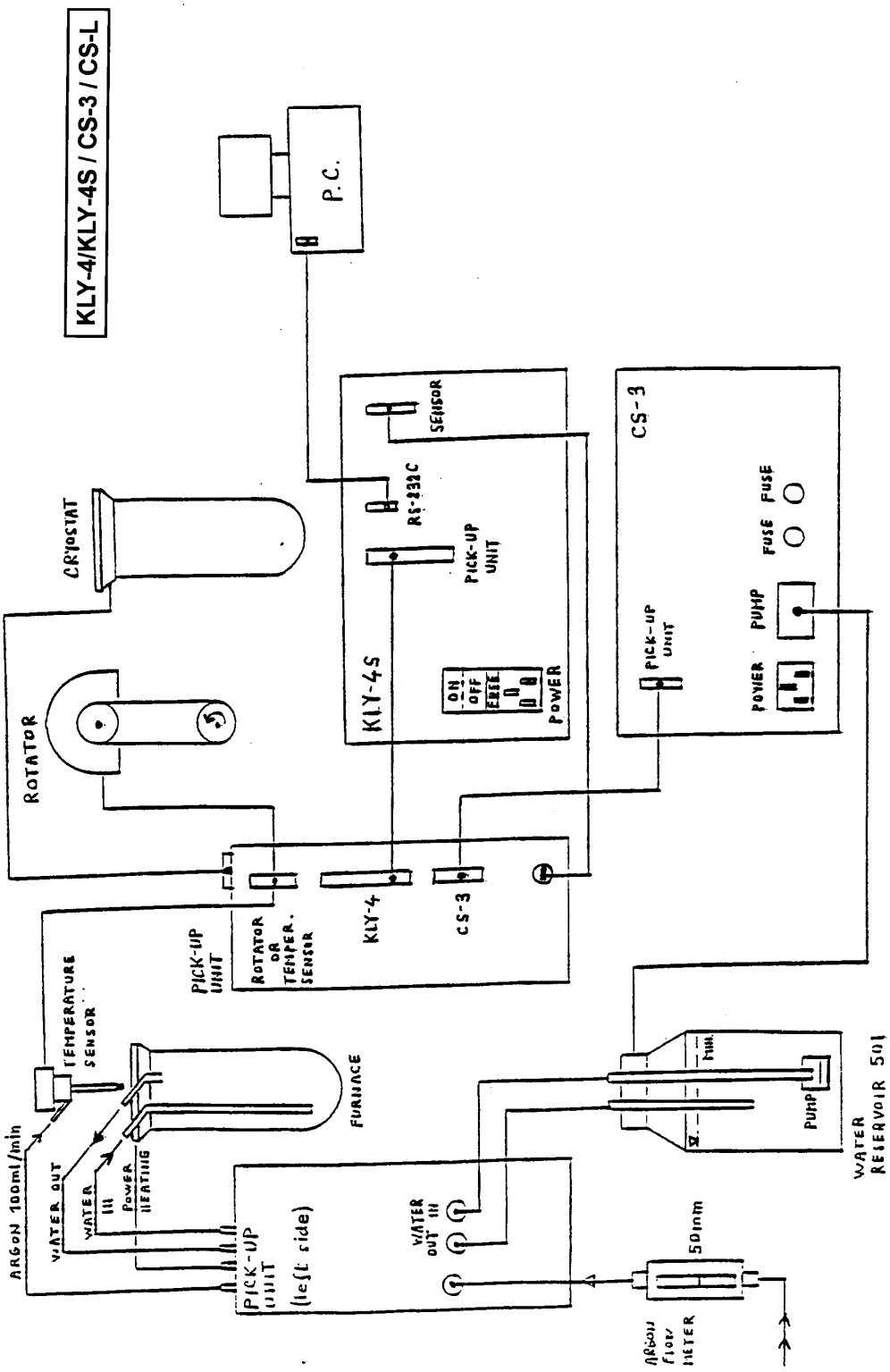

Fig. 1 KLY-4(S) / CS-3 Interconnection Scheme

Testing the communication with computer

- Copy the software SUFAR and SUFAM (for KLY-4) to your computer exactly in the same structure as it is on original diskette and run program SUFAR.EXE or SUFAM.EXE.

- After the program is started the communication of the instrument with your computer via serial channel RS-232C is tested automatically each time you run the program SUFAR or SUFAM. If there is something wrong in the communication, the following message appears on the screen :

  #### RS-232 COMMUNICATION ERROR

  Current communication port: COM1

  For change edit the file SUFAR.SAV

- In this case it is recommended to switch the instrument off and to check the connection of the instrument with the computer as well as to check whether the correct serial port number is set in the configuration file SUFAR.SAV or SUFAM.SAV.

- If the number of the serial channel should be changed, it can be done using any text editor (for example the NORTON Commander).

  One must be very careful in this operation, because the SUFAR.SAV file is the random access file and the port number must be changed only through overwriting the number, but without affecting the other information contained in the file and retaining the original format of the file. Then, the program should be started once again after switching on the instrument.

- If the communication is O.K., the following information subsequently appear on the screen of the computer :

  - **SUFAR** program :

    In case the initialization of the Up/Down Mechanism, of the Rotator and the Zeroing of the bridge were successful :

    Initialization in progress...

    ** LEVEL SET

    ** AUTO RANGE

    ** FIELD SET H = 300 A/m

    Zeroing in progress ...

    ** END OF ZEROING

    ** READY

- **SUFAM** program :

  In case the Zeroing of the bridge was successful :

  ** AUTO RANGE

  ** FIELD SET H = 300 A/m

  Zeroing in progress ...

  ** END OF ZEROING

- These information inform the user of the current activities of the instrument. In case the communication test was successful, and there are no other problems, the offer of the MAIN MANU appears. For detailed information and explanation of the main menu see chapter Operating Basics. Press <Ctrl Q> to quit the program.

- In the case that something fails during initialization for some reasons (for example, too strong disturbing magnetic fields in the vicinity of the pick up coil) the following message appears :

  F A T A L E R R O R

  E7 ZEROING ERROR (*blinking)*

  Press any key to return to AUX menu

- If you wish to finish the program press <Ctrl Q> .

Testing the magnetic environment

- Connect the multimeter (using a single two-wire cable - it is in the holder box) to the KLY-4S control unit rear panel.
- Run program SUFAM.EXE or SUFAR.EXE.
- In the MAIN menu select function Key 10 AUX, then function Key 8 Acmd and start the zeroing process by pressing <Z>. (During zeroing you can hear the sound whose frequency is approximately proportional to the level of unbalance of the bridge).
- Immediately after and only after you obtain message ** END OF ZEROING, read the voltage level on the multimeter. This voltage is approximately proportional to the level of magnetic environmental background, should not be higher than 1 Volt and should not be changing quickly.
- If you do not use notebook with LCD display (we recommend it), take attention to your PC monitor. The monitor distance from pick-up coils and its azimuth position can have sometimes great influence. Try to rotate the monitor and/or pick-up coils about the vertical axis, zero the bridge again, read the voltage value on multimeter. Repeat several times and try to find the best configuration, when the voltage value is minimal. Usually it is possible to obtain about 0.5 V, but there is no reason to be nervous if it is higher but below 1 V.

Operating Basics

This chapter covers the following topics:

- ❒ Measuring of AMS using KLY-4 and program SUFAM
  - ▪ Measuring Menu of the SUFAM
- ❒ Measuring of AMS using KLY-4S and program SUFAR
  - ▪ Measuring Menu of the SUFAR
- ❒ Auxiliary Menu of the SUFAM and SUFAR
- ❒ Appendices
  - ▪ List of Magnetic Anisotropy Factors
  - ▪ Structures of Data Files
  - ▪ Selection of Coordinate Systems
  - ▪ Geological Locality Data

Measuring of AMS Using Program SUFAM

Purpose

This program serves for on line measurement of the anisotropy of magnetic susceptibility of rocks using the KLY-4 Kappabridge (static specimen method). During measurement process, the susceptibility of the specimen is measured subsequently in 15 directions following the rotatable design in exactly the same way as in the KLY-2 or KLY-3 Kappabridges. Using the least squares method, the susceptibility tensor is fit to these measurements of the 15 directional susceptibilities and the errors of the fit are calculated. The results of the measurement, in the form of various parameters derived from the susceptibility tensor and orientations of the directions of the principal susceptibilities in various coordinate systems, are presented on the screen, can be printed using the line printer or written on the disk. The tensor elements together with orientations of mesoscopic foliations and lineations can be also written on the disk (into standard AMS file which is binary random access file) from where they can be read in advanced processing.

Running Program

After the SUFAM.EXE is started, the information how to terminate the program appears on the screen

<Ctrl Q> EXIT ,

the communication of the instrument with the computer is tested and the bridge is automatically zeroed.

If there is no zeroing problem, the offer of the MAIN MENU appears

1 **15dir** 2 Corr 3 4 5 **Field** 6 **ActVol** 7 **Help** 8 9 **Kill** 10 **Aux**

This menu serves for the measurement of the specimen using program SUFAM.

Do not forget to install the plastic cylinder into the coil before the measurement with SUFAM program.

Measuring Menu of Sufam

The individual function keys start the following activities:

F1 - measurement of the AMS in 15 directions

F2 - correction (repetition) of current position

F5 - field set or

evaluation of the measured data (activated only after all measurements F1 are completed)

F6 - setting up the actual volume of the measured specimen

F7 - invoking the HELP page

F9 - breaking the current activities and clearing current specimen data

F10 - activation of the AUXILIARY MENU

Function Key 1 ***15dir*** Sufam

This procedure serves for the measurement of 15 directional susceptibilities. The design of the 15 directions is shown in the Fig. 2. The position design is the same for the cubic and cylindrical specimens. After pressing F1, the following picture appears on the screen

DATA MEASURED RESIDUALS

Next direction 1

Press <SpaceBar> to continue

- One puts the specimen into the holder in the position 1 (see Fig. 2), presses the SpaceBar key and waits the computer's beep. Then, one inserts the specimen into the measuring coil from where one pulls it out after the second beep. Then, one changes the specimen's position and continues analogously until all the 15 directional susceptibilities are measured.

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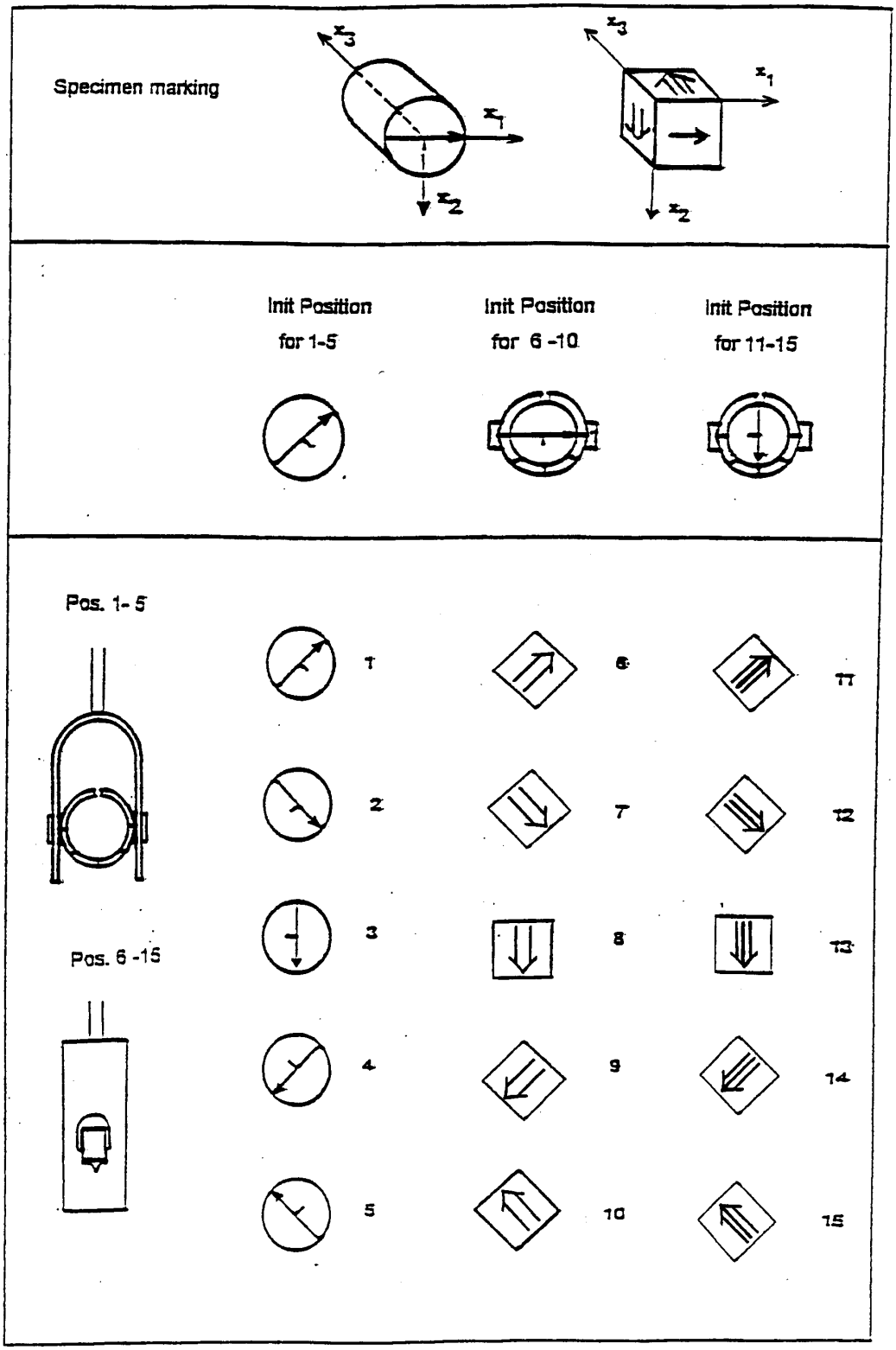
Fig. 2 Measuring positions of the specimen

SUFAM



The results look like in the following example

DATA MEASURED			RESIDUALS in %		
30.41E-03	*32.25E-03*	*31.54E-03*	*-0.12*	*-0.19*	*0.03*
31.27E-03	*31.42E-03*	*31.79E-03*	*-0.11*	*-0.13*	*0.05*
30.60E-03	*31.20E-03*	*32.63E-03*	*-0.13*	*-0.28*	*-0.12*
30.44E-03	*32.33E-03*	*31.60E-03*	*-0.02*	*-0.05*	*0.24*
30.29E-03	*31.45E-03*	*31.85E-03*	*-0.03*	*-0.02*	*0.22*
				Std. error :	*0.18*

Anisotropy test	*:*	*356.1*	*322.9*	*135.6*
Confidence angles	:	*3.3*	*5.1*	*2.0*

1 2 **Corr** 3 4 5 **Eval** 6 7 8 9 **Kill** 10 **Aux**

- The three columns DATA MEASURED show the values of 15 directional susceptibilities measured. The data RESIDUALS represent the deviations of the measured and fitted data. After fitting the susceptibility ellipsoid to the measured data using the least squares method, the susceptibility in each measuring direction is calculated from the fitted tensor and subtracted from the measured value; this is the residual. The residuals are the lower the higher is the measuring accuracy and better fit. Ideally, the residuals are as low as the measuring errors of individual directional susceptibilities. Std. error is the mean value of the absolute values of the residuals.

- The quality of the measurement can be evaluated also from the values of *Anisotropy test* and *Confidence angles*. The Anisotropy test values are the values of the F-test for anisotropy/isotropy and for triaxial/rotational prolate and for triaxial/rotational oblate ellipsoids. If the left value is higher than 3.48, then the differences between the principal susceptibilities determined by measurement compared to measuring errors are great enough that the specimen can be considered anisotropic from the statistical point of view (on the 95 % level of significance). If the central and right values are higher than 4.25, then the ellipsoid is triaxial. The Confidence angles values are those of the angles defining the statistical accuracy of the determination of the directions of the individual principal susceptibilities on the 95 % level of significance (for more details see AGICO Print No. 1).

Fig. 2 Measuring positions of the specimen

Function Key 2 ***Corr*** Sufam

This key may be activated during and after the 15 directional susceptibilities are measured (during the measurement pressing **Corr** sets the position number to the current position minus one). It enables any imprecisely measured directional susceptibility to be re-measured. After complete measurement and after pressing F2, one has to input the *Direction to be repeated* and re-measure the corresponding directional susceptibility. The proper specimen position should be prepared before pressing F2 key. The re-measurements in various directions can be repeated until the expected accuracy is reached.

Function Key 5 ***Eval*** Sufam

This procedure evaluates the measured data through the determination of the susceptibility tensor and its related parameters. Before this procedure is activated, it is possible to repeat measurement of any of the 15 directional susceptibilities in order to get the best data for the evaluation. After the evaluation is once started, neither of the directional susceptibilities can be re-measured; only the whole specimen can be re-measured.

- If the **Eval** procedure is started for the first time, the following questions subsequently appear on the screen

  Path ? drive:\ dir1\dir2\...\ <CR>...current

  Name of file ? without extension, 8 chars max.

  Each of associated files contains *x* record(s)

  Specimen name (# means new file) ?

- After the above information are input, the question appears for the way of inputting the geological orientation data

➪ Select:

Using geological file [1]

Manual input from memo-book [2]

Non-oriented specimen [3]

➪ One selects [1] if the data should be read from the geological data file created earlier (the geological data file can be created using the program ANISOFT program package) which is located in the same directory as the standard AMS file being measured. The reading is made automatically by the computer. The geological data are used in the calculations and also copied into the standard AMS file (see Appendix 2).

➪ If one selects [2], the following questions appear on the screen

MANUAL INPUT FROM MEMO-BOOK

2 sampling angles ?

One inputs the angles of the orientation of the specimen, the first is azimuth of the fiducial mark of the specimen, the second is the dip or plunge of the fiducial mark, for details see the AGICO Print No. 6.

Number of tectonic systems (0 to 2):

- If 0 is input (for example if non-foliated and non-lineated volcanic or plutonic rock is measured), no other geological data are input.
- If 1 or 2 is input, the following data must also be input

  1: Code, 4 tectonic angles ?

  The two-character code characterizes the measured mesoscopic foliation and lineation, the angles are azimuth of the dip (or strike if the orientation parameter P4 is 90), dip of the first mesoscopic foliation, trend, plunge of the first mesoscopic lineation, respectively. If only foliation exists, the second character in the code must be zero and the last two angles are also zeros.
- If 2 is input, the following data must also be input

  2: Code, 4 tectonic angles ?

  The two-character code characterizes the measured mesoscopic foliation and lineation, the angles are azimuth of the dip (or strike if the orientation parameter P4 is 90), dip of the second mesoscopic foliation, trend, plunge of the second mesoscopic lineation, respectively. If only foliation exists, the second character of the code must be zero and the last two angles are also zeros.

➪ If one selects [3], no angle data are necessary.

- After the geological data are input the program displays the results and after pressing ESC key, the program asks

  Output to file [Y/N] <CR> = YES

  Output to printer [Y/N] <CR> = NO

- These questions concern the calculated data which appear later on the screen. They can be written to the file on the disk and/or on the paper using the line printer. If they are written on the disk, they are written as an ASCII file in the same format as they appear on the screen (later they can be re-printed on the paper if necessary). The extension of this file is ASC and the file is located in the same directory as the standard AMS file.
- After measuring the second or later specimen only the question for the specimen name appears on the screen. The data are handled in the same way as those of the first specimen. If one wishes to change the file, one inputs # instead of the specimen name and the inputting is made as in the first specimen.

- Then, the calculated data are shown on the screen in the form whose example is shown on the next page. The meaning of the presented results is as follows :

Azi	first orientation angle (mostly azimuth of the dip or strike of the fiducial mark on the specimen)
Dip	second orientation angle (dip of the fiducial mark or plunge of the cylinder axis)
O.P.	orientation parameters (see the section **OrPar**)
Nom.vol.	nominal volume of the used pick up unit (mostly $10cm^3$)
Act.vol.	the volume of the specimen measured (in cm^3)
Demag.fac.	information whether the demagnetizing factor of the specimen was considered in the calculation of the mean susceptibility
Holder	susceptibility of the holder (measured in the section **Hol**)
T1	code for the first pair of mesoscopic foliation and lineation
F1	orientation angles for the first foliation
L1	orientation angles for the first lineation
T2	code for the second pair of mesoscopic foliation and lineation
F2	orientation angles for the second foliation
L2	orientation angles for the second lineation

Mean	mean susceptibility
Norming factor	norming factor for calculation of the normed susceptibility tensor
Standard err. [%]	error in fitting the susceptibility tensor of the measured data
F, F12, F23	statistics for anisotropy, triaxiality and uniaxiality testing
Normed principal susceptibilities	principal susceptibilities normed by the norming factor and errors in their determination
95% confidence angles, E12, E23, E13	confidence angles (on the 95 % probability level) in the determination of the orientations of the principal susceptibilities

Anisotropy factors	values of the selected anisotropy parameters
Principal directions	orientations of principal susceptibilities (in decreasing succession) as declination (D) and inclination (I) in various coordinate systems
Normed tensor	values of the normed susceptibility tensor in the appropriate coordinate system; the upper line gives the diagonal tensor elements (consecutively K11, K22, K33),while the lower line gives the non-diagonal elements (K12, K23, K13)

NJC8-1 ANISOTROPY OF SUSCEPTIBILITY Program SUFAM ver.1.0
******

Azi 30 O.P. : 12 0 3 90 Nom. vol. 10.00
Dip 60 Demag. fac. : NO Holder -5.15E-06 Act. vol. 8.00

T1	F1	L1	T2	F2	L2
CD	100/20	30/40	SO	140/60	70/80

Field [A/m]	Mean susc.	Standard err. [%]	Tests for anisotropy F	F12	F23
300	199.2E-06	0.22	271.2	33.9	363.7

Normed principal susceptibilities			95% confidence angles E12	E23	E13
1.0323	1.0139	0.9537	10.1	3.1	2.4
+- 0.0014	0.0014	0.0014			

Anisotropy factors (principal values positive)

L	F	P	'P	T	U	Q	E
1.018	1.063	1.082	1.087	0.546	0.532	0.265	1.044

		Principal directions			Normed tensor		
Specimen system	D	241	76	344	0.9591	1.0115	1.0294
	I	4	3	85	0.0166	-0.0041	-0.0080
Geograph system	D	164	278	13	0.9695	1.0117	1.0188
	I	63	11	24	-0.0119	-0.0029	-0.0288
Paleo 1 system	D	127	264	8	0.9654	1.0176	1.0169
	I	51	31	21	0.0162	0.0094	0.0074
Tecto 1 system	D	187	324	68	1.0141	0.9690	1.0169
	I	51	31	21	0.0173	0.0211	-0.0151
Paleo 2 system	D	91	187	356	0.9818	1.0320	0.9862
	I	5	47	43	0.0018	0.0036	-0.0368
Tecto 2 system	D	111	207	16	0.9865	1.0273	0.9862
	I	5	47	43	-0.0126	-0.0072	-0.0294

➪ The data page can be left by pressing ESC key.

Function Key 6 ***ActVol*** Sufam

This procedure serves for inputting the actual volume of the measured specimen. If all the specimens measured in a particular collection have the same volume, it is sufficient to input this volume only once. If the volume varies from specimen to specimen, it is necessary, before or after the measurement of each specimen (but at least before the evaluation of the measured data), to input the correct volume of the measured specimen.

- After starting this procedure, the volume written in the configuration file appears on the screen in the following form :

  Actual volume ccm

  10

  Any changes [Y/N] ?

- If the volume of the measured specimen is the same, one only hits ENTER, while if the volume is different, one should input Y and then the actual volume of the measured specimen.

Function Key 7 ***Help*** Sufam

This key invokes the help procedure. To quit help page press ESC key.

Function Key 9 ***Kill*** Sufam

This key breaks the current activities and clears the measured and input specimen data.

Function Key 10 ***Aux*** Sufam

This key switches the program to the AUXILIARY MENU.

Measuring of AMS Using Program SUFAR

Purpose

This program serves for on line measurement of the anisotropy of magnetic susceptibility of rocks using the KLY-4S Kappabridge (spinning specimen method). During measurement, the specimen slowly rotates subsequently about three perpendicular axes. The bridge is zeroed after inserting the specimen into the measuring coil so that susceptibility differences are measured during specimen spinning (64 measurements are made during one spin) which results in very sensitive determination of the anisotropic component of the susceptibility tensor profiting from the measurement on the lowest possible and therefore most sensitive range. Then, one bulk susceptibility value is measured along one axis and the complete susceptibility tensor is combined from these measurements. The measured data, in the form of various parameters derived from the susceptibility tensor and orientations of directions of the principal susceptibilities in various coordinate systems, are presented on the screen, can be printed using the line printer or written on the disk (into a sequential ASCII file). The tensor elements together with orientations of mesoscopic foliations and lineations can be also written on the disk (into standard AMS file which is binary random access file) from where they can be read in advanced processing.

Running Program

After the SUFAR.EXE is started, the information how to terminate the program appears on the screen

<Ctrl Q> EXIT

and the communication of the instrument with the computer is automatically tested.

- If communication failed check configuration file SUFAR.SAV (see also the chapter Testing the communication with computer).
- If the communication is O.K., the following information subsequently appear on the screen of the computer

  Initialization in progress...

  ** LEVEL SET

  ** AUTO RANGE

  ** FIELD SET H = 300 A/m

  Zeroing in progress ...

** END OF ZEROING

** READY

These are information of the current activities of the instrument.

- In the case that initialization or zeroing failed for some reasons (for example, too strong disturbing magnetic fields in the vicinity of the pick up coil) the following message appears

  F A T A L E R R O R

  E7 ZEROING ERROR *(blinking)*

  Press any key to abort program

- If there is no initialization or zeroing problem, the offer of the MAIN MENU appears

1 **Ax1** 2 **Ax2** 3 **Ax3** 4 **Bulk3** 5 **Field** 6 **ActVol** 7 **Help** 8 Stop 9 **Kill** 10**Aux**

This menu serves for the measurement of the specimen using program SUFAR.

Do not forget to remove the plastic cylinder from the coil in case the SUFAM program was used in the last session.

Measuring Menu of SUFAR

The individual function keys start the following activities:

F1 the specimen spins about the *x1* axis (measurement of the AMS in the *x2*,*x3* plane of the specimen - Position No.1)

F2 the specimen spins about the *x2* axis (measurement of the AMS in the *x2*,*x3* plane of the specimen - Position No.2)

F3 the specimen spins about the *x3* axis (measurement of the AMS in the *x1*,*x2* plane of the specimen - Position No.3)

F4 measurement of the bulk susceptibility in the Position No.3

F5 field set or evaluation of the measured data (activated only after the measurements F1 to F4 are completed)

F6 setting up the actual volume of the measured specimen

F7 invoking the HELP page

F8 stops the current measurement and sets up the rotator to the initial position

F9 the program breaks the current activities and clears current specimen data

F10 activation of the AUXILIARY MENU

Function Key 1 ***Ax1*** Sufar

This procedure serves for the measurement of the AMS in the *x1*,*x2* plane (the specimen spins about the *x1* axis). The spinning is very slow (one revolution per 2 seconds) and the susceptibility is measured 64 times during one revolution. As the bridge is zeroed with the specimen inserted into the measuring coil before the specimen starts spinning, the susceptibility differences are measured between the susceptibilities along the respective directions and that of the direction in which the bridge was zeroed. This way of measurement is very advantageous, because one measures only the anisotropic component of the susceptibility which is much lower than the bulk component and one can profit from the higher accuracy of the measurement made on the more sensitive range.

- Before pressing Key F1, one has to fix the specimen into the specimen holder in the measuring position No. 1 (see Fig. 3).

- After pressing F1, the specimen is inserted into the specimen coil, the bridge is zeroed and the specimen starts spinning; during spinning the specimen susceptibility is measured.

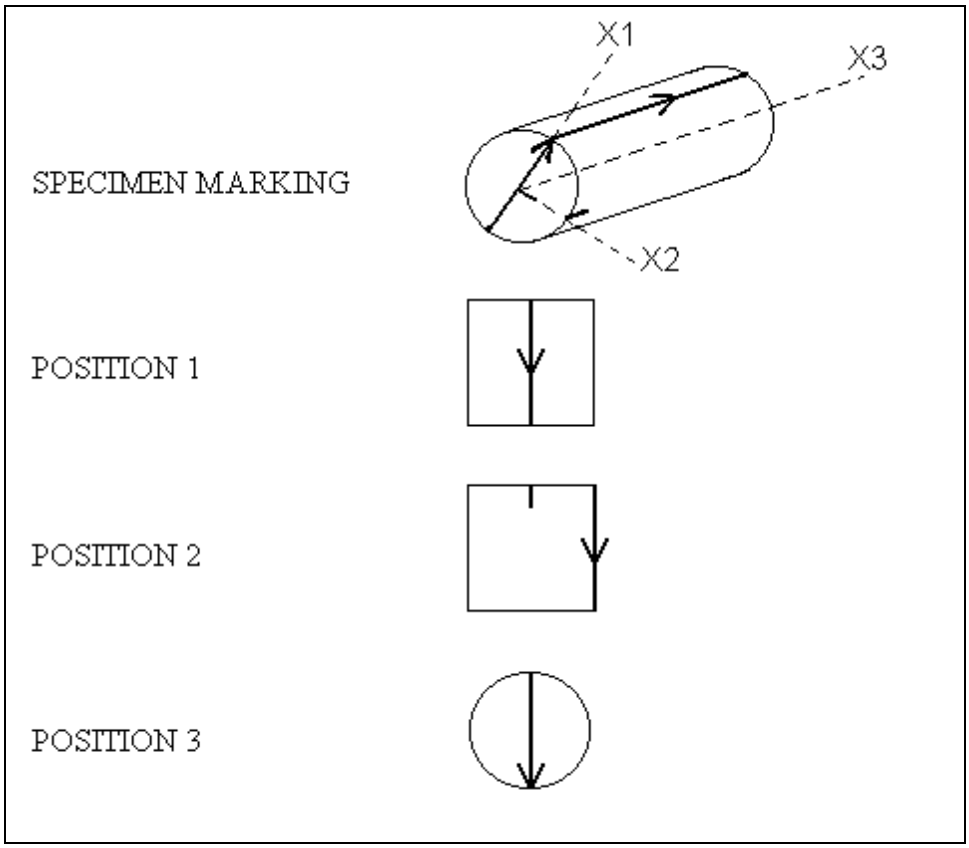


Fig. 3 Measuring positions of the specimen

The results are presented in the form as in the following example

Ax	Range	Cosine	Sine	Error	Error%
1	*1*	*-5.709E-06*	*-2.102E-06*	*8.2E-09*	*0.14*

- *Ax* means that the specimen spinned about the *x1* axis (the measurement was made in the *x2,x3* plane - Position No.1).
- *Range* informs us of the range on which the anisotropy was measured (this is only formal information, because the instrument has a fully autoranging feature).
- *Cosine* and *Sine* give the values of the cosine and sine components, respectively, of the average anisotropy curve.
- *Error* gives the standard deviation of the individual curves from the average curve.
- *Error%* gives this deviation divided by the amplitude value.

The *Error* you obtain in each of three AMS axes measurement is standard deviation of the individual curves (there are two sine wave curves for one physical revolution) from the average curve and the *Error%* gives this deviation divided by the amplitude value. This errors has only informative meaning and reflect the ratio between the noise and aniso signal for measurement in one plane only. Thus it depends not only on absolute susceptibility of the specimen measured but mainly on the degree of anisotropy in an individual plane perpendicular to the axis of rotation. In case there is no anisotropy in one of the three planes this error may be over 100% and has no physical meaning. In case the anisotropy in one plane has "reasonable" value, the usual value is lower 5%, but it does not reflect the quality of the measurement, but the level of anisotropy in one plane. On the other hand it is clear that the sensitivity of the instrument influeces this error. For judgement of the quality of AMS measurement, use F test numbers and 95% confidence angles. The general rule is follow. If the F numbers are high (let say at least above 5) the confidence angles are low and principal direction (directions) is (are) very well defined. The sensitivity of AMS measurement for field 300 Am^{-1} on KLY-4S is $2x10^{-8}$, the anisotropy of the specimens with mean susc. about $5x10^{-6}$ SI can be measured, but the confidence angles may be in some cases higher, it depends on type of anisotropy.

Function Key 2 ***Ax2*** Sufar

This procedure serves for the measurement of the AMS in the *x1,x3* plane (the specimen spins about the *x2* axis - Position No.2) in the same way as in the previous case.

Function Key 3 ***Ax3*** Sufar

This procedure serves for the measurement of the AMS in the *x1,x2* plane (the specimen spins about the *x3* axis - Position No.3) in the same way as in the previous case.

Function Key 4 ***Bulk3*** Sufar

This procedure measures the bulk susceptibility along the *x1* axis (corresponding to the specimen in the third measurement position). After pressing F4, the bridge is zeroed, the specimen is inserted into the measuring coil and the bulk susceptibility is measured.

- The knowledge of the bulk susceptibility along the *x1* axis is necessary in the construction of the complete susceptibility tensor from the deviatoric tensor (based on susceptibility differences) and one bulk value

Function Key 5 ***Field*** Sufar

After pressing the Fkey the required Field can be entered. The value is automatically rounded into the row of 21 available Fields. Below 10 A/m in step of 2 A/m, upper 10 A/m up to 100 A/m in step of 10 A/m and upper 100 A/m up to 450 A/m in step of 50 A/m.

Function Key 5 ***Eval*** Sufar

This procedure evaluates the measured data through the determination of the susceptibility tensor and its related parameters. Before this procedure is activated, it is possible to repeat any of the procedures **Ax1**, **Ax2**, **Ax3**, **Bulk3** in order to get the best data for the evaluation. When any of the above procedures is completed, the denotation of the respective key is supplemented by an asterisk *. After the evaluation is once started, neither of the above procedures can be repeated; only the whole specimen can be re-measured.

- If the **Eval** procedure is started for the first time, the following questions subsequently appear on the screen

  Path ? drive:\ dir1\dir2\...\ <CR>...current

  Name of file ? without extension, 8 chars max.

  Each of associated files contains *x* record(s)

  Specimen name (# means new file) ?

- After the above information are input, the question appears for the way of inputting the geological orientation data

➪ Select:

Using geological file [1]

Manual input from memo-book [2]

Non-oriented specimen [3]

➪ One selects [1] if the data should be read from the geological data file created earlier (the geological data file can be created using the ANISOFT program package) which is located in the same directory as the standard AMS file being measured. The reading is made automatically by the computer. The geological data are used in the calculations and also copied into the standard AMS file (see Appendix 2).

➪ If one selects [2], the following questions appear on the screen

MANUAL INPUT FROM MEMO-BOOK

2 sampling angles ?

One inputs the angles of the orientation of the specimen, the first is azimuth of the fiducial mark of the specimen, the second is the dip or plunge of the fiducial mark, for details see the AGICO Print No. 6.

Number of tectonic systems (0 to 2):

- If 0 is input (for example if non-foliated and non-lineated volcanic or plutonic rock is measured), no other geological data are input.

- If 1 or 2 is input, the following data must also be input

  1: Code, 4 tectonic angles ?

  The two-character code characterizes the measured mesoscopic foliation and lineation, the angles are azimuth of the dip (or strike if the orientation parameter P4 is 90), dip of the first mesoscopic foliation, trend, plunge of the first mesoscopic lineation, respectively. If only foliation exists, the second character in the code must be zero and the last two angles are also zeros.

- If 2 is input, the following data must also be input

  2: Code, 4 tectonic angles ?

  The two-character code characterizes the measured mesoscopic foliation and lineation, the angles are azimuth of the dip (or strike if the orientation parameter P4 is 90), dip of the second mesoscopic foliation, trend, plunge of the second mesoscopic lineation, respectively. If only foliation exists, the second character of the code must be zero and the last two angles are also zeros.

➪ If one selects [3], no angle data are necessary.

- After the geological data are input the program displays the results and after pressing ESC key, the program asks

  Output to file [Y/N] <CR> = YES

  Output to printer [Y/N] <CR> = NO

- These questions concern the calculated data which appear later on the screen. They can be written to the file on the disk and/or on the paper using the line printer. If they are written on the disk, they are written as an ASCII file in the same format as they appear on the screen (later they can be re-printed on the paper if necessary). The extension of this file is ASC and the file is located in the same directory as the standard AMS file.

- After measuring the second or later specimen only the question for the specimen name appears on the screen. The data are handled in the same way as those of the first specimen. If one wishes to change the file, one inputs # instead of the specimen name and the inputting is made as in the first specimen.

- Then, the calculated data are shown on the screen in the form whose example is shown on the next page. The meaning of the presented results is as follows :

Azi	first orientation angle (mostly azimuth of the dip or strike of the fiducial mark on the specimen)
Dip	second orientation angle (dip of the fiducial mark or plunge of the cylinder axis)
O.P.	orientation parameters (see the section **OrPar**)
Nom.vol.	nominal volume of the used pick up unit (mostly 10cm^3)
Act.vol.	the volume of the specimen measured (in cm^3)
Demag.fac.	information whether the demagnetizing factor of the specimen was considered in the calculation of the mean susceptibility
Holder	susceptibility of the holder (measured in the section **Hol**)
T1	code for the first pair of mesoscopic foliation and lineation
F1	orientation angles for the first foliation
L1	orientation angles for the first lineation
T2	code for the second pair of mesoscopic foliation and lineation
F2	orientation angles for the second foliation
L2	orientation angles for the second lineation

Mean	mean susceptibility
Norming factor	norming factor for calculation of the normed susceptibility tensor(equal to the absolute value of the mean susceptibility)
Standard err. [%]	error in fitting the susceptibility tensor of the measured data
F, F12, F23	statistics for anisotropy, triaxiality and uniaxiality testing
Normed principal susceptibilities	principal susceptibilities normed by the norming factor and errors in their determination
95% confidence angles, E12, E23, E13	confidence angles (on the 95 % probability level) in the determination of the orientations of the principal susceptibilities

Anisotropy factors	values of the selected anisotropy parameters
Principal directions	orientations of principal susceptibilities (in decreasing succession) as declination (D) and inclination (I) in various coordinate systems
Normed tensor	values of the normed susceptibility tensor in the appropriate coordinate system; the upper line gives the diagonal tensor elements (consecutively K11, K22, K33),while the lower line gives the non-diagonal elements (K12, K23, K13)

9-4-1 ANISOTROPY OF SUSCEPTIBILITY Program SUFAR ver.1.0
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Azi 30 O.P. : 12 0 3 90 Nom. vol. 10.00
Dip 60 Demag. fac. : NO Holder -1.67E-06 Act. vol. 11.00

T1	F1	L1	T2	F2	L2
CD	100/20	30/40	SO	140/60	70/80

Field [A/m]	Mean susc.	Standard err. [%]	Tests for anisotropy F	F12	F23
300	127.9E-06	0.042	2953.2	2055.3	1564.5

Normed principal susceptibilities			95% confidence angles Ax1	Ax2	Ax3
1.0304	0.9985	0.9711	1.6	1.9	0.9
+- 0.0003	0.0003	0.0003	0.9	1.6	1.9

Anisotropy factors (principal values positive)

L	F	P	'P	T	U	Q	E
1.032	1.028	1.061	1.061	-0.063	-0.078	0.738	0.996

		Principal directions			Normed tensor		
Specimen	D	283	193	68	1.0000	1.028	0.9715
system	I	4	3	85	-0.0069	0.0046	0.0004
Geograph	D	40	146	305	1.0095	0.9973	0.9932
system	I	9	60	28	0.0254	0.0124	-0.0028
Paleo 1	D	34	152	284	1.0153	0.9890	0.9957
system	I	26	44	35	0.0162	0.0194	0.0074
Tecto 1	D	94	212	344	0.9815	1.0228	0.9957
system	I	26	44	35	0.0033	0.0161	-0.0131
Paleo 2	D	229	42	133	0.9878	0.9868	1.0254
system	I	67	23	2	0.0160	-0.0095	-0.0068
Tecto 2	D	249	62	153	0.9774	0.9972	1.0254
system	I	67	23	2	0.0126	-0.0112	-0.0031

➪ The data page can be left by pressing ESC key

Function Key 6 ***ActVol*** Sufar

This procedure serves for inputting the actual volume of the measured specimen. If all the specimens measured in a particular collection have the same volume, it is sufficient to input this volume only once. If the volume varies from specimen to specimen, it is necessary, before or after the measurement of each specimen (but at least before the evaluation of the measured data), to input the correct volume of the measured specimen.

- After starting this procedure, the volume written in the configuration file appears on the screen in the following form :

  Actual volume ccm

  10

  Any changes [Y/N] ?

- If the volume of the measured specimen is the same, one only hits ENTER, while if the volume is different, one should input Y and then the actual volume of the measured specimen.

Function Key 7 ***Help*** Sufar

This key invokes the help procedure. To quit help page press ESC key.

Function Key 8 ***Stop*** Sufar

This key stops the current measurement and sets up the rotator to the initial position.

Function Key 9 ***Kill*** Sufar

This key breaks the current activities and clears the measured and input specimen data.

Function Key 10 ***Aux*** Sufar

This key switches the program to the AUXILIARY MENU.

Auxiliary Menu of SUFAR and SUFAM

This menu is usually used to input the auxiliary information into the program useful during the measurement of all the specimens in one measuring shift.

Convention

To help you quickly find the information, the name of the Key of the Auxiliary Menu is denoted as Function AKey, instead of Function Key in Measuring (Main) Menu, to underline that the key of Auxiliary menu is mentioned. Examples of measurement values are expressed in *Italic.*

After activating Auxiliary menu, the following offer appears in *SUFAR* program

1 **Bulk** 2 **Etal** 3 **Cal** 4 **Hol** 5 **Orpar** 6 **Anfac** 7 **Help** 8 **Acmd** 9 **Kill** 10 **Main**

In the program Sufam the menu is the same.

The individual keys start the following procedures:

F1 measurement of the bulk susceptibility only (without AMS) of a specimen. It can be useful in susceptibility monitoring between demagnetization steps in palaeomagnetism.

F2 checking and/or inputting the susceptibility value for the used calibration standard

F3 instrument calibration

F4 measurement of the susceptibility of the specimen holder

F5 checking and/or setting up the values of the orientation parameters

F6 checking and/or setting up the set of the parameters characterizing the rock AMS

F7 invoking the help procedure

F8 auxiliary commands

- Enable and Disable movement Up/Down (available for KLY-4S)
- checking the Up and Down movement (available for KLY-4S)
- Zeroing of the bridge
- Field set
- List of Parameters

F9 the program breaks the current activities

F10 return to the MAIN MENU

Function AKey 1 ***Bulk***

This procedure serves for measurement of the bulk susceptibility (for example in monitoring the susceptibility changes due to the demagnetization steps in palaeomagnetism).

- After starting the procedure, the following information appear on the screen :

  Measurement of bulk susceptibility

  The current holder susceptibility : *-2.57 E-6*

  New measurement of holder [Y/N] ?

- If one inputs Y, the procedure Key 4 **Hol** is made. If one inputs N or <CR>, the procedure continues by bulk measurement in current Field - select <F>, or by measurement of the bulk field variation Curve in all available fields - select <C>.

  In case of individual bulk measurement any measurement is started by pressing <CR>. Then the bridge is zeroed, wait for a beep and insert (KLY-4 only) the specimen into the pick-up coil, wait for second beep and pull (KLY-4 only) the specimen out.

  To finish measurements, type **Q**

N	Specimen	Bulk
1	*XY*	*-4.58E-06*
2	*STANDARD*	*82.75E-03*
3	***Q***	

- After inserting the specimen into the specimen holder and inputting the specimen name, the bulk susceptibility is measured using manual holder. The measurement is terminated after inputting Q instead of the specimen name. The bulk susceptibility is calculated using the specimen volume which is entered in procedure Key 6 ActVol.

Function AKey 2 ***Etal*** Sufar

This procedure serves for checking and setting the nominal values of the calibration standard.

- Please note that the instrument is calibrated by two values. This is because the calibration standard gives not only the directional bulk susceptibility value, but also the anisotropy which is derived from the susceptibility along the *x3* axis of the standard and from that along the direction perpendicular to the *x3* axis.

- After activating this procedure through pressing the AKey F2, the following information appear on the computer screen.

Etalon	Bulk-max	Bulk-min
	136.7 E-03	*27.00 E-03*

Any Changes [Y/N]

- If both the *Bulk-max* and *Bulk-min* values are the same as those written on the etalon to be used for the instrument calibration, one inputs N or <CR> and the procedure is terminated.

- If any or both the values are different, one has to input Y and then the correct values of both the *Bulk-max* and *Bulk-min*. Then, the procedure is finished.

- Note: If you change the calibration standard nominal value(s), the *Holder* is reset to zero. (See AKey 3 and AKey 4).

Function AKey 2 ***Etal*** Sufam

After activating this procedure through pressing the AKey F2, the following information appear on the computer screen

Etalon	Susc.	
	136.7 E-03	(the higher value of the two written on the standard)

Any Changes [Y/N]

- If the *Susc.* value is the same as the higher one written on the standard to be used for the instrument calibration, one inputs N or <CR> and the procedure is terminated.

- If the value is different, one has to input Y and then the correct value. Then, the procedure is finished.

- Note: If you change the calibration standard nominal value, the *Holder* is reset to zero. (See AKey 3 and AKey 4).

Function AKey 3 ***Cal*** Sufar

This procedure serves for the calibration of the instrument. This calibration is made as for the bulk susceptibility value along the *x3* axis of the standard as well as for the anisotropy represented by the susceptibility difference between the standard susceptibility along the *x3* axis and the perpendicular direction (the standard is fixed in the holder in the first measuring position, see Fig. 3).

- After activating this procedure through pressing the AKey F3, the calibration procedure starts and the following information subsequently appear on the computer screen

AUX 300 A/m ** ANISO

CALIBRATION : 05-15-2003 08:13:47

	Bulk	Cos	Sin	Delta	GainA	GainB
OLD	*136.7 E-03*	*54.85 E-03*	*0.00 E+00*	*-22.77*	*1.0023*	*1.0005*
MEAS	*136.6 E-03*	*54.84 E-03*	*38.51E-06*	*-22.77*	*1.0023*	*1.0005*
NEW	*136.7 E-03*	*54.85 E-03*	*0.00 E+00*	*-22.81*	*1.0027*	*1.0008*

➪ Press <CR> to save calibration data

- *Bulk* displays the values of the bulk susceptibility of the standard along the x3 axis.
- *Cos* shows the value of the cosine component of the anisotropy of the standard.
- *Sin* shows the value of the sine component of the anisotropy of the standard.
- *Delta* value represents the phase lag of the measured signal relatively to the position of the spinning specimen. This lag is mainly due to the phase characteristics of the output low-pass filter.
- *GainB* is the correction for getting the total gain for the bulk susceptibility to be measured precisely.
- *GainA* is the correction for getting the total gain for the anisotropy to be measured precisely.
- The line headed “OLD” gives the above data of the last calibration corresponding to those written in the configuration file.
- The line “MEAS” gives the data actually measured standard assuming that *Delta*, *GainB* and *GainA* values equal “OLD” values.

- The line headed “NEW” shows the result of the above measurement, but with proper new corrections *Delta, GainB, GainA*. The constants *Delta, GainB, GainA* are also written into the configuration file.

- The data are systematically checked to warn, if needed, the operator to prevent writing results into the configuration file. Thus, the *GainB* and *GainA* values should be within the interval of 90% to 110% of the old values, otherwise the error is indicated.

- Note: If you change the calibration standard nominal value, the *GainB* and *GainA* are undefined for current field until proper calibration is performed successfully.

Function AKey 3 ***Cal*** Sufam

This procedure serves for the calibration of the instrument. After pressing AKey F3, the following message appear :

Calibration in current Field

➪ Insert calibration standard after first (longer) beep

... Pull out it after second (shorter) beep

Press <SPACE> bar if you are ready to continue

- Before pressing any key, it is necessary to put the standard into the holder in such a way that the cylinder axis is vertical and after pressing space bar one has to follow the above instructions.

The calibration results are shown as follows

AUX 300 A/m ** BULK

CALIBRATION : 05-15-2003 08:13:47

	Bulk	Gain
OLD	*136.7 E-03*	*1.0001*
MEAS *136.5 E-03*	*1.0001*	
NEW	*136.7 E-03*	*1.0016*

➪ Press <CR> to save calibration data

- The column *Bulk* displays the values of the bulk susceptibility of the standard along the *x3* axis. *Gain* is the correction for getting the total gain for the bulk susceptibility to be measured precisely.

- Note: If you change the calibration standard nominal value, the *Gain* is undefined for current field until proper calibration is performed successfully.

Function AKey 4 ***Hol*** Sufar

This procedure consists of the measurement of the bulk susceptibility and anisotropy of the empty holder in the field **300 A/m**. This susceptibility and anisotropy are written into the configuration file and subtracted from the measured values after measuring the specimen.

- After activating this procedure through pressing the AKey F4, the measurement of the empty holder starts and the following information subsequently appear on the computer screen

AUX 300 A/m ** BULK (** ANISO)

HOLDER	Bulk	Cos	Sin
Old values	*-4.138E-06*	*-10.E-09*	*-2.7E-09*
	-4.179E-06	*-29.E-09*	*-19.E-09*
	-4.140E-06	*-36.E-09*	*-13.E-09*
	-4.113E-06	*-11.E-09*	*-14.E-09*
New values	*-4.144E-06*	*-25.E-09*	*-15.E-09*
Std.error	*33.E-09*	*13.E-09*	*3.5.E-09*

➪ Press <CR> to save the data and complete this routine

- In the beginning of the procedure the *Old values* data appear on the screen. These are the data stored in the configuration file obtained in the last measurement of the empty holder.

- The bulk susceptibility of the empty holder is automatically measured three times, its mean value and standard error of the average are calculated. Afterthat, the anisotropy of the empty holder is measured three times and the mean value and standard error of the average are also calculated.

- If the measurements are inconsistent (for example, if holder bulk susceptibility does not lie within the interval between -20E-06 to +5E-06 or the standard error is greater than 0.1×10^{-6}) the New values are blinking, indicating that the procedure is recommended (in some cases needed) to be repeated.

Function AKey 4 ***Hol*** Sufam

This procedure consists of the measurement of the bulk susceptibility of the empty holder in the field **300 A/m**. This susceptibility is written into the configuration file and subtracted from the measured values after measuring the specimen.

- After activating this procedure through pressing the AKey F4, the following message appears on the screen :

  HOLDER measurement is repeated 3 times

  ➪ Insert empty holder after first (longer) beep

  ... Pull it out after second (shorter) beep

  Press <SPACE> bar if you are ready to continue

- Then, one has to follow the above instructions. The results of the measuring empty holder are presented as follows

  AUX 300 A/m ** BULK

  H O L D E R

  Old value : *-3.314E-06*

  New value : *-3.310E-06*

	Susc	Error	Drift
1	*-3.305E-06*	*5.2E-09*	*-480E-09*
2	*-3.269E-06*	*41.E-09*	*-430E-09*
3	*-3.356E-06*	*-46.E-09*	*-360E-09*
Resulting	*-3.310E-06*	*44.E-09*	*-420E-09*

  ➪ Press <CR> to save the data and complete this routine

- The *Old value* is the holder susceptibility of the last measurement, stored in the configuration file. Then, the bulk susceptibility of the empty holder is measured three times, its mean value and standard error of the average are calculated. If the measurements are inconsistent (for example, if holder bulk susceptibility does not lie within the interval of -10 E-06 to +0 E-06 the *New value* is blinking,

indicating that the procedure is recommended (in some cases needed) to be repeated.

- Note: If you change the calibration standard nominal value, the *Holder* is reset to zero.

Function AKey 5 ***Orpar***

The scientists use different ways of sampling oriented specimens. In order to respect these differences we have developed such a software solution of the data transformation from the specimen coordinate system to the geographic, palaeogeographic and tectonic coordinate systems that it is controlled through the so called orientation parameters. In this way, any oriented sampling is possible. For definition of these orientation parameters and more details see AGICO Print No. 6.

- The program shows the set of current orientation parameters

  Orientation parameters

  P1 = 6

  P2 = 0

  P3 = 6

  P4 = 0

  Any changes [Y/N] ?

- If one enters N or free string, the shown parameters are used in the subsequent calculations.

- If one enters Y, new parameters are set up. Computer asks for inputting the P1, P2, P3 and P4 parameters and displays them on the screen. These new parameters are written into a configuration file and are displayed, if the program is started again.

Function AKey 6 ***Anfac***

Magnetic fabric can be visualized by the shape and orientation of the anisotropy ellipsoid. The eccentricity and shape of the ellipsoid can be characterized by conveniently chosen parameters derived from the principal values (parallel to the axes of the anisotropy ellipsoid). Unfortunately, more than 30 parameters have been suggested for this purpose, even though 2 parameters are sufficient to characterize the eccentricity and shape. Some of them are listed in the enclosed Table. As it is not reasonable to present them all, our program selects 8 parameters according to the demands of the user.

- The selection is made as follows. First, the set of the previously used parameters appear on the screen (Current anisotropy factors) together with the question *Any changes [Y/N] ?*

- If one does not wish to change this set, one enters *N* or free string, the program prints *Factors saved* and continues in function.

- If one wishes to change this set, one enters *Y* and the program shows the table of factors from which one can select new set and asks Count of factors and one has to input the number of selected factors (in our case 8). Then one enters the number of factors and the name (abbreviation) of the factor delimited by comma. This is repeated till the whole set is introduced. After entering the last factor the program displays again the whole set and asks *Any changes [Y/N]*. In the case that one needs to do any change one has to repeat the whole procedure. If not, one enters *N* or free string to terminate the procedure.

Function AKey 7 ***Help***

Pressing this key invokes the help procedure. To quit help page press ESC key.

Function AKey 8 ***Acmd*** Sufar

This routine allows to set the field, zero the bridge, allows the rotator to be moved up and down without measurement. The up/down movement can be also enabled or disabled. The parameters of SUFAR.SAV and PAFA.SAV files can be listed.

Function AKey 8 ***Acmd*** Sufam

This key allows to set the field and zero the bridge. The parameters of SUFAM.SAV and PAFA.SAV files can be listed.

Function AKey 9 ***Kill***

The programs breaks the current activities and clear current specimen data.

Function AKey 10 ***Main***

Return from Auxiliary menu to the MAIN MENU.

Appendices

This chapter covers the following topics

- List of Magnetic Anisotropy Factors.
- Structures of Data File.
- Selection of Coordinate Systems.
- Geological Locality Data.

List of Magnetic Anisotropy Factors

Factor No.		*Mathematical expression*	*Usual Abbreviation*
1.		(15/2)[(k1-k)^2+(k2-k)^2+(k3-k)^2]/(3*k)^2	
2.	➪	exp{sqr[2((n1-n)^2+(n2-n)^2+(n3-n)^2)]}	P'
3.		sqr{2[(n1-n)^2+(n2-n)^2+(n3-n)^2]}	ln P'
4.	➪	k1/k3	P
5.		ln(k1/k3)	ln P
6.		100(k1-k3)/k1	
7.		(k1-k3)/k2	
8.		(k1-k3)/k	
9.	➪	k1/k2	L
10.		ln(k1/k2)	ln L
11.		(k1-k2)/k	
12.		2k1/(k2+k3)	
13.	➪	k2/k3	F
14.		ln(k2/k3)	ln F
15.		(k1+k2)/(2k3)	
16.		(k1+k3)/(2k2)	
17.		2k2/(k1+k3)	
18.		1-k3/k2	
19.		(2k1-k2-k3)/(k1-k3)	
20.		(k1+k2)/2-k3]/k	
21.		(k2-k3)/k	
22.		k1/sqr(k2*k3)	
23.		(k1*k3)/(k2^2)	
24.	➪	(k1-k2)/[(k1+k2)/2-k3]	Q
25.		(k1-k2)/(k2-k3)	
26.		(k2-k3)/(k1-k2)	
27.		arcsin{sqr[(k2-k3)/(k1-k3)]}	
28.	➪	(k2^2)/(k1*k3)	E
29.		k2(k1-k2)/[k1(k2-k3)]	
30.		(k2/k3-1)/(k1/k2-1)	
31.	➪	(2n2-n1-n3)/(n1-n3)	T
32.	➪	(2k2-k1-k3)/(k1-k3)	U
33.		(k1+k2-2k3)/(k1-k2)	
34.		sqr{[(k1-k)^2+(k2-k)^2+(k3-k)^2]/3}/k	R
35.		(k1*k2*k3)^(1/3)	
36.		k3(k1-k2)/[k1(k2-k3)]	
37.		k3(k1-k2)/(k2^2-k1*k3)	
38.		(k1-k2)(2k1-k2-k3)/[(k2-k3)(k1+k2-2k3)]	

k1>k2>k3 are principal normed susceptibilities and n1, n2, n3 are their respective natural logarithms, the symbol

➪ means default set of AGICO (stored in PAFA.SAV configuration file of a new instrument)

Structures of Data Files

The programs Sufar and Sufam work with the following data and configuration files :

- The following notation is used for variables denotation :

  n$ *n* bytes string variable
  2I two bytes integer variable
  4R four bytes real variable

- The classical sequential ASCII file with extension **.ASC** contains the printable output results of measured specimen(s), in the same form as on the screen.

- The Standard Anisotropy File (AMS) contains the results of the anisotropy measurement in binary form and has extension **.RAN**

- The Geological Data File contains only the geological data (orientations of specimens and of mesoscopic fabric elements), its extension is **.GED**

- File **Pafa.SAV** contains current set of orientation parameters and anisotropy factors.

- Files **Sufar.SAV** and **Sufam.SAV** contain serial port number, calibration standard values, instrument gain and phase coefficients calculated during calibration procedure for field 300 A/m, holder components measured during holder correction routine and actual current volume of specimen. Note: These files remain compatible with older Susar.SAV and Susam.sav files used for KLY-3S / KLY-3.

- Files **CalKly4.SAV** for Sufar.exe and **CalKly4m.sav** for Sufam.exe contain instrument gain coefficients for all available fields.

- Files **Sufar.TMP** and **Sufam.TMP** contain the screen contents results of the last specimen measured.

- File **Bulk.TMP** contains the screen contents in measuring bulk susceptibility using routine **Bulk** invoked by function AKey 1. This file can be saved as **xxx.KY4** for future post processing.

- Files **Sufar.HLP** and **Sufam.HLP** contain the Help page.

Structure of Standard AMS File

The STANDARD ANISOTROPY FILE is a random access file with the length of the record being 64 bytes.

Structure of the First Line (Record)

2I	16$	7$	7$	4$	4$	4$	4$	4x3$	4$
N+2	LOCALITY	LONGI	LATI	ROCK	STRATI	LITHO	REGIO	ORIENT.P.	EOL

- The first record contains the locality data:

N+2	number of specimens in the file+2,
LOCALITY	name of locality,
LONGI	geographical longitude of the locality,
LATI	geographical latitude of the locality,
ROCK	rock type,
STRATI	stratigraphical position,
LITHO	lithostratigraphy,
REGIO	regional position,
ORIENT	orientation parameters P1, P2, P3, P4,
EOL	end of line sequence.

Structure of the Other Lines (Records)

12$	4R	4R	6x4R	2$	2x2I	2x2I	2$	2x2I	2x2I
SPEC	CHAR	NORM	K11 to K33	C1	FOLI1	LINE1	C2	FOLI2	LINE2

- The second and the following records contain the specimen data. Each record contains:

SPEC	*name* of the specimen,
CHAR	*mean susceptibility* in the order of 10^{-6} SI,
NORM	*absolute value of the mean susceptibility* in the order of 10^{-6} SI,
K11, K22, K33, K12, K23, K13	*components of normed AMS tensor* in the geographic system,
C1	*code* for the *1st* pair of mesoscopic foliation and lineation,
FOLI1	*azimuth of dip* and *dip* of the *1st foliation,*
LINE1	*trend* and *plunge* of the *1st lineation,*
C2	*code* for the *2nd* pair of mesoscopic foliation and lineation,
FOLI2	*azimuth of dip* and *dip* of the *2nd foliation,*
LINE2	*trend* and *plunge* of the *2nd lineation.*

Structure of Geological Data File

The GEOLOGICAL DATA FILE is a random access file with the length of the record being 64 bytes. The numerical data are for practical reasons recorded as strings so that they can be directly checked.

Structure of the First Line (Record)

4$	16$	7$	7$	4$	4$	4$	4$	4x3$	2$
N+2	LOCALITY	LONGI	LATI	ROCK	STRATI	LITHO	REGIO	ORIENT.P.	EOL

- The first record contains the locality data:

N+2	number of specimens in the file+2,
LOCALITY	name of locality,
LONGI	geographical longitude of the locality,
LATI	geographical latitude of the locality,
ROCK	rock type,
STRATI	stratigraphical position,
LITHO	lithostratigraphy,
REGIO	regional position,
ORIENT	orientation parameters P1, P2, P3, P4,
EOL	end of line sequence.

Structure of the Other Lines (Records)

12$	2x4$	4$	2x4$	2x4$	4$	2x4$	2x4$
SPEC	ORIENTATION	CODE1	FOLI1	LINE1	CODE2	FOLI2	LINE2

- The second record and the following records contain the specimen data. Each record contains:

SPEC	*name* of the specimen,
ORIENTATION	*azimuth*[1] and *dip*[2] of the fiducial mark orienting the specimen,
CODE1[A]	*code* for the *1st* pair of mesoscopic foliation and lineation,
FOLI1	*azimuth*[1] *of dip* and *dip*[3] of the *1st foliation*,
LINE1	*trend*[1] and *plunge*[3] of the *1st lineation*,
CODE2	*code* for the *2nd* pair of mesoscopic foliation and lineation,
LINE2	*trend* and *plunge* of the *2nd lineation*,
FOLI2	*azimuth of dip* and *dip* of the *2nd foliation*,
LINE2	*trend* and *plunge* of the *2nd lineation*,
FREE	four characters free string.

[1] values from 0 degrees to 360 degrees
[2] values from 0 degrees to 180 degrees
[3] values from 0 degrees to 90 degrees
[A] for the reason of compatibility with the AMS file only 2 characters are recommended to be used

Note : The orientation of mesoscopic foliation should be measured in terms of azimuth of dip and dip or strike and dip and this is indicated by the orientation parameter P4 (see the section *Orientation Parameters*). The azimuth of dip or strike should be measured as angles ranging from 0 to 360 degrees (not from zero to 180 degrees) and they are recorded in the geological data file as measured. However, in the standard anisotropy file they are recorded in terms of azimuth of the dip and dip. This is made automatically when the anisotropy is measured on line or the anisotropy is measured in the specimen coordinate system and later transformed into the geographical coordinate system using the program EFILE (function [8]) and this must be kept in mind in the case of manual creation of the anisotropy data file.

Selection of Coordinate Systems

The orientations of magnetic foliation and magnetic lineation can be presented not only in the standard geographical coordinate system, but also in the so-called palaeo-geographical system (after rotation of the mesoscopic foliation under consideration into the horizontal position about the corresponding lineation) or in the so-called tectonic coordinate system (mesoscopic lineation and foliation are the coordinate axes). The program can work with up to 2 pairs of mesoscopic foliation and lineation which are described by a two-character code. The first character of the code describes the foliation, while the second character describes the lineation (for the proposal of the codes see the enclosed table). For example, the code characterizing the existence of metamorphic schistosity and mineral alignment lineation is SA. If only the foliation and no lineation exist, the second character in the code is zero. For example, the system characterized by the bedding only has the code B0 (zero).

Codes characterizing mesoscopic foliations and lineations :

Code	*Foliation*	*Code*	*Lineation*
B	bedding	A	mineral alignment
C	cleavage	D	bedding/cleavage intersection
K	cataclastic schistosity	F	fold axis
S	metamorphic schistosity	R	striation
J	joint	W	wave hinge lineation
G	igneous banding	P	current direction
E	fluidal foliation	M	beta axis
H	schlieren foliation	L	lava flow lineation
N	lava flow foliation	O	schlieren lineation

Geological Locality Data

The inputting of the locality data is not compulsory. The **ANISOFT** package of programs for advanced AMS data processing does not work with the locality data. These data serve only for storing the locality geological characteristics on the disk.

In inputting the locality geological data, the following data are asked for.

- NAME OF LOCALITY (max. 16 characters, ENTER means no data)

  This is the literary name of the locality, it serves only as a note characterizing the locality location, etc.

- LOCALITY GEOGRAPHICAL LONGITUDE (DECADICAL EXPRESSION)
- LOCALITY GEOGRAPHICAL LATITUDE (DECADICAL EXPRESSION)

  Both in the format xxxx.xx. These data are input as decadical expressions, not using minutes and seconds.

- ROCK TYPE (max. 4 characters)
- STRATIGRAPHY (max. 4 characters)
- LITHOSTRATIGRAPHY (max. 4 characters)
- REGIONAL (max. 4 characters)

  These data are recommended to be input as 3 character codes; their purpose is to characterize geologically the locality investigated, they are not used in further calculations.

- ORIENTATION PARAMETER P1
- ORIENTATION PARAMETER P2
- ORIENTATION PARAMETER P3
- ORIENTATION PARAMETER P4

  (See also Appendix - Selection of Coordinate System)

Maintenance

Cleaning the Holder

It is recommended to clean the specimen holders regularly, especially if you continue with measurement of relatively weak specimens after measuring strong ones. For cleaning use pure water with a small amount of detergent and soft brush.

Cleaning the Rotator

From time to time, it is necessary to clean the shell in which the specimen is fixed during the measurement, and the other part of the rotator.

- Loosen three screws which fix the upper black cover of the motor and remove it carefully by pulling it up. Then loosen a little bit (do not remove it) two screws B, see Fig. 4., but before loosening this screws check the belt strain to set it later in the same level. After loosening this screws, the strain of the tooth belt eases and the specimen shell can be removed from its bearing.
- Clean the shell, the belt and the bearing. For cleaning use pure water with a small amount of detergent and soft brush.
- If upper tooth wheel should be cleaned, loosen six screws A - Fig. 4, and clean it too.
- Clean the black wheel with 64 notches, optocouples and photosensor from dust using soft dry brush. Check if all 64 notches are transparent.
- Before assembling dry up everything properly.

- During assembling pay attention to the following three points:

  - the strips on the upper wheel are in the same line
  - the strips on specimen shell are in the same line
  - the white belt mark is approximately in the centre of the photosensor

- Fix the two screws B, adjust the proper belt strain by picking-up slightly the part with motor.
- Finally set the motor cover and fix it by screws.

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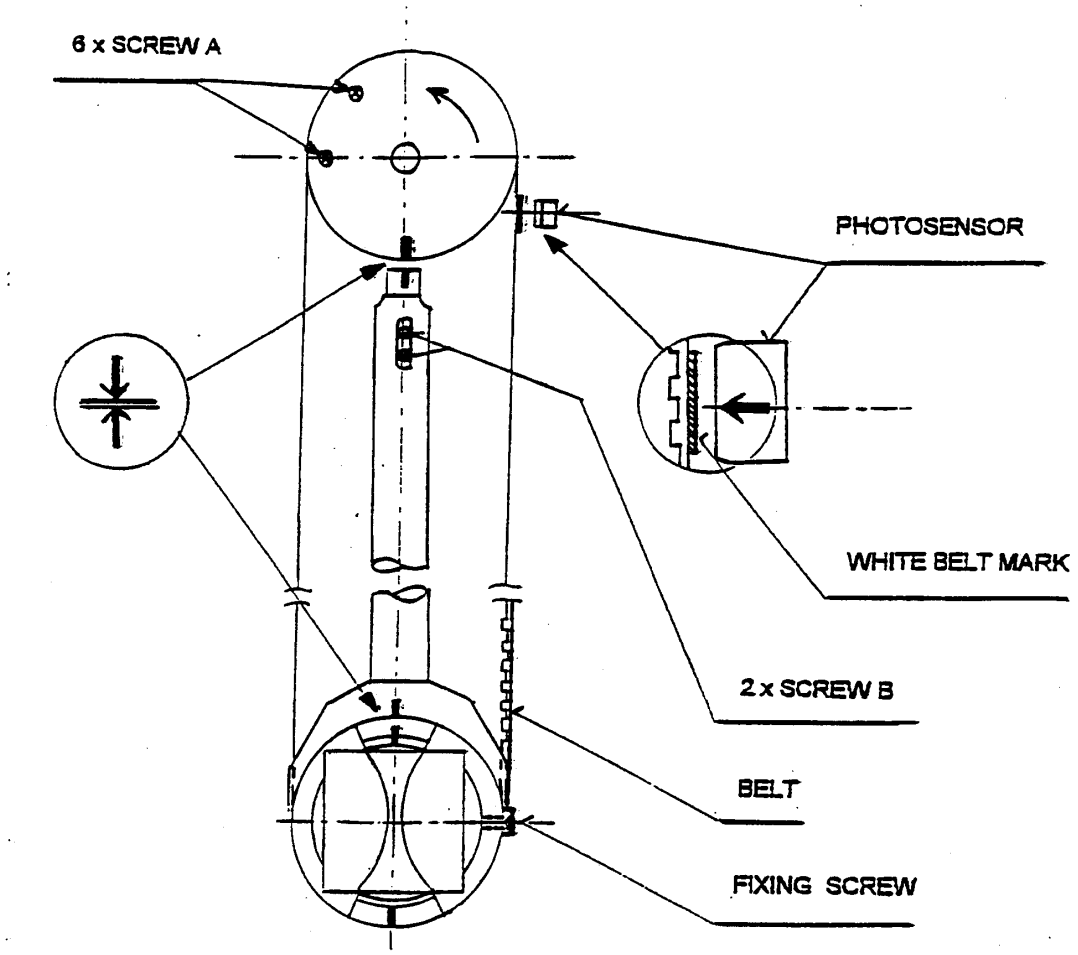
KLY-4S Rotator - Belt Adjustment

Fig. 4 KLY-4S Belt Adjustment



Cleaning the Up/Down Mechanism

The Up/Down Mechanism should be cleaned in case the mechanism makes suspicious noise during movement and/or if the time of the movement of the holder from lower to upper position is longer than 3.5 s. The Up/Down execution time can be checked using *AKey 8* in Axiliary Menu of Sufar program.

- Set the Up/Down Mechanism to down position *(AKey 8)* and switch off the instrument.
- Remove the rear panel of the Pick-Up Unit (so that you can see inside).
- After loosening the small screw remove the arm of the holder. Check the position of the white teflon ring to reinstall it later into the same position and angle orientation. Then remove the screw and the washer and, at last, the white teflon ring.
- Using two cleaning papers clean the space inside the cylinder. Insert the papers into the gap between the inner cylinder and outer tube and clean the inner cylinder space by moving papers along inner surface of the cylinder and simultaneously by moving them a little bit up and down.
- Clean the ring also and reinstall it, checking its proper position and angle orientation inside the cylinder. Tighten the screw fixing the washer gently.
- For easier manipulation it is recommended to use the following size and shape of cleaning paper. Paper strip about 30 cm in length of trapezoid shape, with bases 5 and 2 cm, thickness of about 0.1 mm.

- Do not lubricate the inner cylinder by any lubricant. In case the cleaning does not fix the problem, do not try to solve it yourself, contact the manufacture.

List of Error Messages of the System KLY-4S / CS-3

Error message	*Description*	*What to do*
E1 INIT. ERR: xxH	initialization of CS-3 xx is hex.number error	switch off and on KLY-4S and ru run SUFTE program again, check all connectors
E2 CS-3 UNIT ON	CS-3 is on while should be off	try to run program once again after switching off and on the KLY-4S
E2 CS-3 UNIT OFF	CS-3 is off while should be on	check the connection between KLY-4S and CS-3
E3 BAD OPTO MAX E3 BAD OPTO MIN E3 BAD STEP MOTOR E3 BAD MAX/MIN	hardware error	contact manufacture
E4 LEVEL ERROR	up/down motor malfunction	check connectors contact manufacture
E4 POSITION ERROR	overflow during measurement of empty coil	check the disturbance sources and interconnection cables
E5 TEMP TOO HIGH	missing (broken) temp. sensor or overheating	check connection of the temperature sensor
E6 VOLT.OVERFLOW		during exchanging rotator for temp.sensor switch off the instrument
E6 VOLT.TIMEOUT	hardware error	contact manufacture
E7 ZEROING ERROR	bridge is unbalanced	check the disturbance sources and connection
E8 BAD COOLING	wrong circulation of cooling water	check the cooling circle, pump connection
E9 BAD REVOLUTION	missing rotator or slow revolution	check connection and motor wires inside rotator

Error message	*Description*	*What to do*
E9 MISSING 1x E9 MISSING 64x	pulse 1x or 64x per revolutin is missing	check opto couples and wires inside rotator
E9 BELT ERROR	missing belt signal	check the belt adjustment and belt mark
E0 SYNTAX ERROR E0 INPUT TIMEOUT E0 BAD COMMAND	illegal parameter or wrong timing unknown command	
** WITHOUT RANGE	range is overflow	specimen is too strong, use smaller one
Unexpected message	other message was received	switch off the instrument while connecting or disconnecting the temperature sensor or rotator
Illegal message	the unknown message was received	check RS 232 serial connection
No message received	timeout passed	check RS 232 serial connection, run only one program at one time
Missing furnace	no furnace installed in the holder	ocures if the SUFTE is run without furnace, which could remain in stanby position
Missing file xxx.SAV	some .SAV file is not present in current dir.	copy the proper .SAV file to your working directory
Wrong heating or temperature sensor	the temperature is not increasing properly	check temperature sensor, contact manufacture
Disconnect Cryostat	the cryostat is connected	unplug the cryostat before running SUFTE
RS-232 Communication error		check the serial port number preset in configuration .SAV file, check RS 232 serial connection

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APPARATUS
CS-3 / CS-L

User's Manual

Supplement for KLY - 4S
User's Manual

Apparatus for measuring temperature
variation of magnetic susceptibility

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Preface

This Supplement is intended for Users who already have Kappabridge KLY-4S and extend the instrument by CS-3 and/or by CS-L Apparatus.

- ❒ The Part 2 of the User's Guide KLY-4/KLY-4S, **Apparatus CS-3 / CS-L**, describes the measurement of temperature variation of magnetic susceptibility using the high temperature furnace CS-3 and low temperature cryostat CS-L.

CS-3 / CS-L Description

The **CS-3 Temperature Control Unit** has been designed for measurement, in connection with the KLY-4S Kappabridge, of the temperature variation of low-field magnetic susceptibility of minerals, rocks and synthetic materials in the temperature range from ambient temperature to 700 ^{o}C. The apparatus consists of non-magnetic Furnace with a special platinum Thermometer, electronic Temperature Control Unit, cooling water Reservoir with Pump, and Argon Flow Meter. The specimen is placed in a measuring vessel which is heated by a platinum wire in three selectable heating rates. The temperature is measured by special platinum thermometer. The protect Argon atmosphere during heating can be applied to prevent oxidation of measured specimen. To perform susceptibility measurement at a chosen temperature range, the equipment moves automatically the furnace into and out of the pick-up coil of the KLY-4S Kappabridge. The quasi-continuous measurement process is fully automated, being controlled by the software **SUFTE.**

The **CS-L Low Temperature Apparatus** has been designed for measurement, in connection with the KLY-4S Kappabridge and CS-3 Temperature Control Unit, of the temperature variation of low-field magnetic susceptibility of minerals, rocks and synthetic materials in the temperature range from minus 192 ^{o}C to ambient temperature. The apparatus consists of non-magnetic Cryostat with a special platinum Thermometer. The specimen is placed in a measuring vessel which is cooled inside the cryostat by liquid nitrogen and then heated spontaneously to a given temperature. The argon gas is needed for deplenishing the liquid nitrogen out of cryostat. Temperature is measured by special platinum thermometer. The quasi-continuous measurement process, after cooling the specimen, is fully automated, being controlled by the software **SUFTEL.**

Special program **CUREVAL** serves for off-line data post processing and graphical representation of the data obtained by measurement of temperature variation of magnetic susceptibility of rocks by means of the CS-3/CS-L High/Low Temperature Apparatus and the KLY-4S Kappabridge.

CS-3 / CS-L Specifications

Maximum specimen volume (fragments or powder)	0.25 cm^{3}
Inner diameter of measuring vessel	6.5 mm
Sensitivity to susceptibility changes	1 x 10^{-7} (SI)
Temperature range CS-3	ambient temperature to 700 ^{o}C
Temperature range CS-L	-192 ^{o}C to ambient temperature
Accuracy of temperature sensor	± 2 ^{o}C
Power requirements	240, 230, 120, 100 V ±10 %, 50 / 60 Hz
Power consumption	350 VA
Dimensions / Mass	
Electronic unit	260 mm x 160 mm x 250 mm / 9 kg
Water container with Pump	380 mm x 380 mm x 700 mm / 2 kg
Argon flow meter	32 mm x 32 mm x 140 mm / 1 kg

Cryostat	diameter 60 mm, length 220 mm / 0.5 kg
Argon gas flow requirement (protect atmosphere)	approx. 100 ml min^{-1}
Amount of liquid nitrogen (cooling cryostat)	approx. 0.5 l for one cooling
Argon gas flow requirement (deplenishing cryostat)	approx. 20 l min^{-1} for about 10 s

Installing and Operating the CS-3 / CS-L

For connection of the CS-3/CS-L to the Kappabridge KLY-4S follow the Interconnection Scheme KLY-4/CS-3, (see Chapter Installation Procedures in Manual Part 1, Kapabridge KLY-4/KLY-4S.)

Furnace

The power for heating the furnace is connected through two wire cables fixed by two screws. The heating wire itself is made of platinum (bifillar winding). The specimen vessel, the heating tube and the insulation tube are made from silicon glass, while the furnace outer tube is made from perspex. The temperature insulation of the furnace consists of a layer of Al_2O_3 powder and a layer of cooling water, respectively.

Temperature Sensor

Thermometer is special platinum sensor whose resistance depends on temperature. Thermometer is connected to the system by 9-pin connector, the same as used for the rotator of the KLY-4S.

- If you connect the thermometer and/or rotator be sure the Kappabridge is off.

- The sensor and the silicon glass pipe are very fragile. For this reason, a very careful manipulation is needed to prevent damaging the pipe when it is inserted in or taken out from measuring tube.

- Temperature sensor should be carefully cleaned after each specimen measurement. For cleaning use cotton-wool, which can be soaked with various solvents (e.g. acetone, spirit), if necessary. After cleaning dry up the sensor.

- Do not use ultrasonic cleaning for thermometer. Take care of outlet wires of the thermometer as well. In any manipulations, do not bend them too much.

Specimen

The basic type of a specimen measured is fine powder of a mineral or rock. Small fragments can also be used - in this case add Al_2O_3 powder to prevent position changes of the fragment(s) during movement up and down. For correct measurement, the specimen should be placed in the area of homogeneous temperature and homogeneous measuring magnetic field. This area extends at the length of 20 mm from the bottom of the specimen vessel. The temperature sensor is placed in the centre of this area. In this case, the measurement of a specimen temperature is the most precise and the measurement of the specimen susceptibility is the most sensitive.

Argon Flow Meter

The protect Argon atmosphere can be used to prevent chemical changes of the specimen during heating. The appropriate flow is about 100 ml/min which corresponds to the level of 50 mm on the argon flow meter.

Measuring Vessel

The specimen silicon glass vessel should be cleaned regularly to achieve the right results.

- Ultrasonic cleaning is a very effective and a very quick procedure for cleaning measuring vessels.
- Cotton-wool wound on a skewer is used for mechanical cleaning of the specimen vessel interior. Cotton-wool can be soaked with various solvents (e.g. acetone, spirit).
- Chemical cleaning is needed if a specimen was smelted during a measurement.

- Contact a chemist for rules for manipulation with acids before using following procedure. Be careful while operating with acids.

  - put acid in a cylindrical vessel made from laboratory glass
  - put acid in the specimen vessel
  - insert the specimen vessel into the acid
  - let acid act for several hours
  - exchange acid several times

- pour acid out

- rinse the specimen vessel with water several times

- dry the vessel carefully

- Some recommended acids:

  a) HCl

  b) H_2SO_4

  c) the strongest acid is the chrome-sulphur acid prepared as follows:

  - use 15g of $K_2Cr_2O_7$ and 200 ml (cm^3) of concentrated H_2SO_4

  - crush finely $K_2Cr_2O_7$ in a porcelain (or achate) mill

  - dissolve this powder in concentrate H_2SO_4

Cooling System

The CS-3 apparatus is equipped with a closed water circle for shielding the pick-up coil of the KLY-4S Kappabridge from the hot furnace. The main parts of the cooling system are double mantle of the furnace, pipes, flow indicator and water container with pump.

- Correct flow of the cooling water is monitored during the operation of the apparatus by control software and by green LED located on the pick-up unit of KLY-4S. The LED is on if sufficient amount of water is flowing. Any interruption of the water flow longer than two seconds is signalled by this LED going off, and the heating of the furnace is automatically switched off and the measurement is interrupted.

- The optimum condition for the measurement is reached when the temperature of water in the container and the temperature in the laboratory are the same. Therefore we recommend to switch on the cooling system approximately 2 hours before starting the measurement every time after new tanking or replenishing the container. Normally this is not necessary, because the temperature of water is equal to the ambient temperature.

- An outlet of warm water (WATER-OUT) of the PICK-UP unit is connected by approx. 2.5 m long tubing with an inlet IN of the water container.

- An outlet of cold water (WATER-IN) of the PICK-UP unit is connected by approx. 2.5 m long tubing with an inlet OUT of the water container.

- The water reservoir must contain approx. 50 litres of distilled water.

- Cable from the pump of the water reservoir should be connected to the socket situated on the CS-3 Temperature Control Unit.

- After first filling with water or after any other aerating of the cooling system, it is necessary to carry out its disaerating. It is recommended to do it after the apparatus has not been in function for a prolonged period of time.

- The process of the disaerating of the cooling system is as follows :

  Connect the CS-3 apparatus to the KLY-4S Kappabridge (see Chapter Installation Procedures, Interconnection Scheme, Fig.1), do not forget to connect temperature sensor and fill the water reservoir by destilled water.

  Switch on the KLY-4S Kappabridge.

  Run the program SUFTE.EXE.

  After activation of the CS-3 the program tests the water circle.

  In case of E8 COOLING ERROR message, open water circle and wait until water without air is running out.

  Close water circle and check if the green led COOLING on Pick-up Unit is on. After this procedure, the cooling system is ready.

Cryostat CS-L

Cryostat is used for measurement of temperature variation of magnetic susceptibility in temperature range -192 ^{o}C to ambient temperature. Before running SUFTEL program, which controls the measurement prepare the cryostat to its operating position.

- Switch off the system.

- Put the high temperature furnace to its standby position without connecting it. Stanby position is the place in the black big hole on the pick-up unit.

- Install the cryostat to the holder and connect the 9-pin connector located on the upper part of the pick-up unit.

- Check if the cryostat is properly mounted in the notch and if the tube for output the liquid nitrogen is not damaged.

Measuring Temperature Variation of Magnetic Susceptibility Using Program SUFTE

Purpose

The program SUFTE serves for on-line measurement of temperature variation of magnetic susceptibility of rocks, by means of the CS-3 Apparatus and KLY-4S Kappabridge, in temperature range from ambient temperature to 700 ^{o}C.

This program requires DOS ver.4.0 and higher, and VGA graphic card.

Running the Program

- Check if the temperature sensor is connected and if the cooling system is closed. If you used in the last session SUFAM prog. remove the plastic cylinder from coil.
- Switch on the KLY-4S / CS-3 system.
- After switching the KLY-4S on, the CS-3 and the pump are switched on for a few seconds (for testing the interconnection between the instruments) and then switched off. The CS-3 and the pump are switched on again later during the initialization by software command.
- Run program SUFTE.EXE.
- After the program is started, the communication of the instrument with the computer via the serial channel RS-232 is tested.
- If communication failed check configuration file SUFTE.SAV. See also the chapter, Testing the communication with computer, in this Manual Part 1.
- If the communication is O.K., the following information subsequently appear on the screen of the computer

  Initialization in progress...

  ** LEVEL SET

  ** AUTO RANGE

  Zeroing in progress ...

  ** END OF ZEROING

  ** READY

  Initialization of CS-3 in progress...

  ** CS-3 READY

After initialization of the CS-3 the screen is cleared, and the following continues

Temperature sensor test Temp: *22.8*

COOLING TEST LOOP COOLING IS O.K.

These are information of the current activities of the instrument.

- In the case that zeroing of the bridge failed for some reasons (for example, too strong disturbing magnetic fields in the vicinity of the pick up coil), or initialization of the CS-3 failed for some reasons, the following message appears *(example)*

  F A T A L E R R O R

  E5 TEMP TOO HIGH *(blinking)*

  Press any key to abort program

  (Error E5 indicates that the temperature sensor is missing)

- If there is no initialization or zeroing problem, the initial menu appears :

Select key F1...F6

F1 MAX. temperature [50 to 700 deg Celsius] : *700*

F1 MIN. temperature [40 to 100 deg Celsius] : *40*

F2 y axis min. susceptibility [SI] : *0*

F2 y axis max. susceptibility [SI] : *0*

F3 heating rate [slow=1 medium=2 fast=3 extra=4] : *3*

F4 linger at tempmax [minutes] : *0*

F5 CONTINUE

F6 Field [2 to 450 A/m] : 300

- By means of the key **F1**, one can choose the maximum and minimum temperatures to which the investigated specimen should be heated and cooled, respectively. The pre-set values are those of the last measured specimen (stored in the configuration file SUFTE.SAV). The values 700 ^{o}C and 40 ^{o}C are set in the new instrument, because they are probably the most common ones useful in the investigation of the most rocks. They are also the limit values. The maximum temperature cannot be chosen higher than 700 ^{o}C (otherwise the message Illegal value appears and the program waits for new input) and the minimum temperature cannot be chosen lower than 40 ^{o}C. In addition, the minimum temperature cannot be set higher than 100 ^{o}C, because of the necessity of cooling the furnace before measuring the next specimen. Within the above interval, the temperatures can be selected. For example, if one investigates pyrrhotite bearing rocks and is

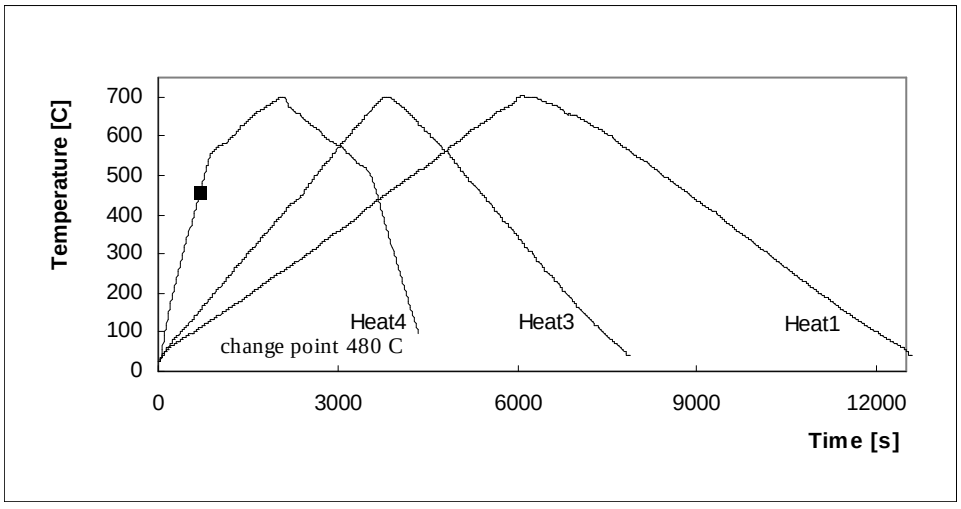
interested only in the Curie temperatures of pyrrhotite, one would select the maximum temperature about 350 °C and considerably save measuring time.

- The key **F2** controls the susceptibility scale of the figure of the susceptibility vs. temperature relationship to be drawn on the screen of the computer during measurement. The default values (0,0) mean that the program selects the suitable scale automatically. If one has some preliminary idea of the susceptibility to be measured, one can choose the scale correspondingly.

- The key **F3** controls the heating rate. The default value heat rate *3* corresponds approximately to the rate of 11 °C per minute which is suitable for the most rocks (heating the specimen up to 700 °C and its cooling down to 40 °C takes approximately 2 1/4 hours). For special studies, slower heating rates can be used (*1* corresponds approx. 6.5 °C/min or *2* - approx. 8.5 °C/min), but one must realize that such as measurements take correspondingly longer time.

  If you select value *4* extra, you are asked to enter temperature point of changing the heating rate. In this case the heat rate is approx. 35 °C/min before point of changing heating rate on heating curve and after point of changing on cooling curve, and approx. 8 °C/min after point of changing on heating curve and before point on cooling curve. It is recommended to set the temperature point at least 50 to 100 °C bellow expected Curie temperature. This option accelerates the measurement in case you are interested in particular Curie temperature.

  Remark: If you set the temperature point of changing heating rate only 30 to 20 °C below max. temperature you can measure all the curve with maximum heating and cooling rate very fast (approx. 40 min. for all curve up to 700 °C). This can be used e.g. for empty furnace measurement or for brief testing purposes. The option heating rate = 4 is not saved in config. file SUFTE.SAV, it must be set before each measurement exclusively.



- The key **F4** controls the time of the thermal treatment of the specimen at the maximum temperature. The default value *0* means that the temperature, immediately after reaching the maximum temperature set by the F1 key, starts decreasing. If longer heating at the maximum temperature is needed, it must be set using the key F4. However, the thermal treatment at the maximum temperature cannot be set longer than 20 min.

- The key **F6** sets the field. After pressing the key the required Field can be entered. The value is automatically rounded into the row of 21 available Fields. Below 10 A/m in step of 2 A/m, upper 10 A/m up to 100 A/m in step of 10 A/m and upper 100 A/m up to 450 A/m in step of 50 A/m.

- The key **F5** is pressed if one agrees with the input data of the entire table and the program continues. First the path for storing the data file should be specified

  Output path (drive:\dir1\dir2\...[CR]current) ?

- Then, the list of files in the specified directory is displayed and file name and furnace name should be input

  Enter file name (without ext.) @-->change path ?

  Name of furnace ?

- If you press <CR> only, the default name furnace is NONAME. After entering the furnace name the following figure appears on the screen

300 A/m Temp: *22.8*

1 **Menu** 2 **ETAL** 3 **CALIB** 4 5 **START** 6 7 8 9 10 **EXIT**

In the frame, the thermomagnetic curve will be drawn when measured.

Key F1 - means return to the initial menu.

Key F2 - the same as in the case of Kappabridge KLY-4.

Key F3 - the same as Kappabridge KLY-4, the holder is operated automatically

Key F5 - activates the measurement procedure.

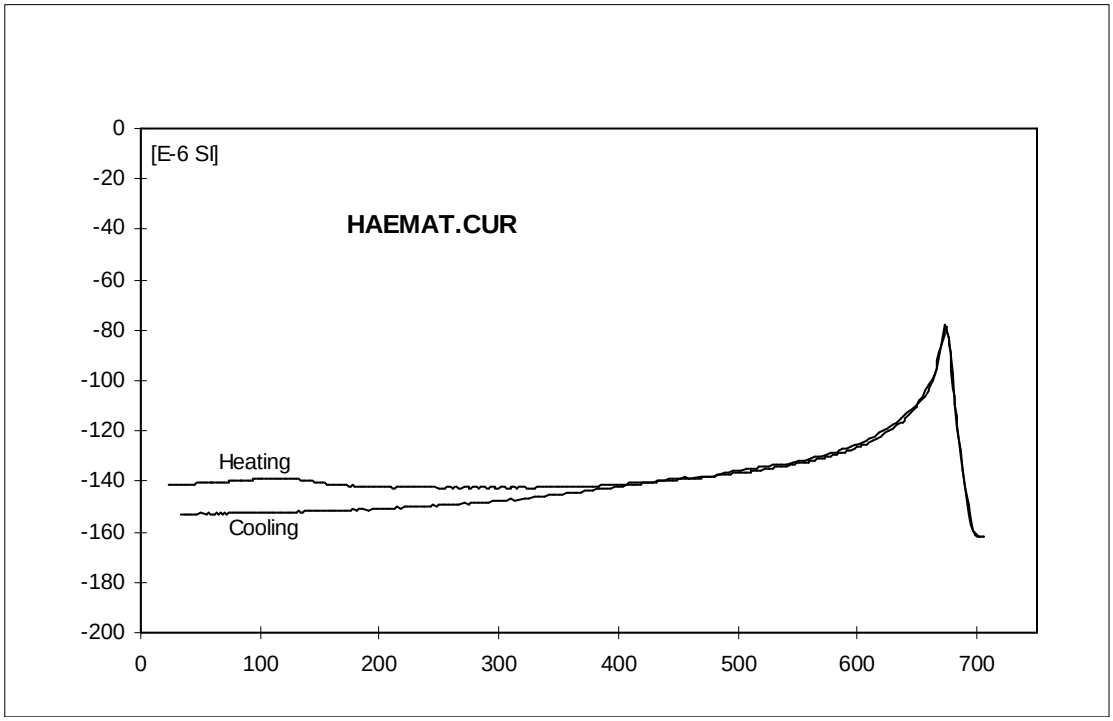
Key F10 - exits the program.

After activating the **START** key F5, the programs starts the measurement of the specimen. Before pressing F5, it is necessary that the powdered specimen is in the measuring vessel, the thermometer is inserted in the specimen and the vessel is inserted in the furnace.

During measuring, the screen of the computer has the outlook, whose example is shown. The cooling curve is illustrated on the screen as dashed line.

**BULK Transferred *xx* % Range *1*

423: susc: *-158.9E-06* 300 A/m Temp: *52.5* Heat:*084* Tmax:*700* Tmin:*40*



1 **Menu** 2 3 4 5 **STOP** 6 7 8 9 10

- The measurement can be aborted any time using STOP Key F5. The heating is switched off , but the program does not terminate until the temperature is lower than 100 ^{o}C .

- Do not manipulate with measuring tube and with the thermometer until the program terminates !

- The message **BULK in the uppermost line alternates during measurement with the message *Zeroing in progress....* It informs the operator that only the bulk susceptibility is measured. The message *Transferred* informs us of how large part of the signal has been transferred from the measuring unit for further evaluation during each Bulk measurement. The message *Range* informs us of the measuring range set up in the autoranging mode to measure the specimen. The leftmost number in the second line (*423* in our example) is the succession number of the measurement of the pair of susceptibility and temperature values.

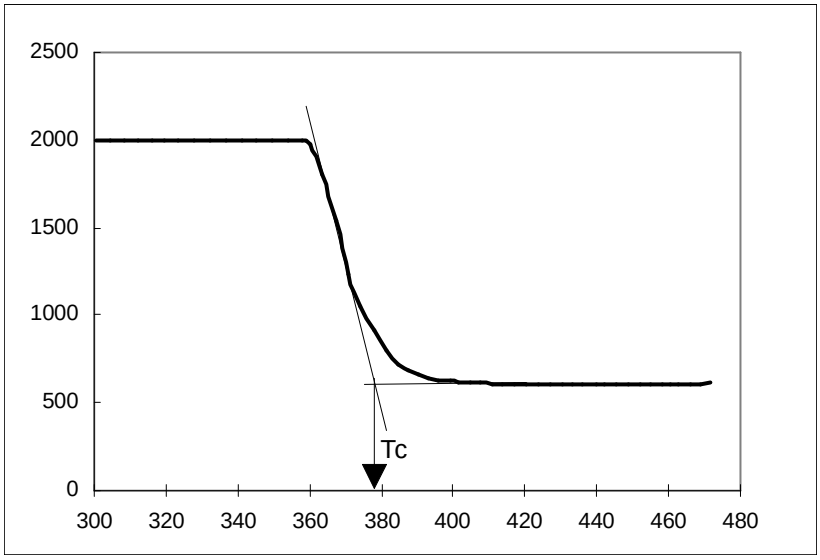
- The *susc.* is the measured total susceptibility value, while *Temp* is the measured temperature value (in degrees centigrade). The value *Heat* contains an information of the heating intensity (in arbitrary units). The values *Tmax* and *Tmin* are the set up values of the maximum and minimum temperatures, respectively.

- The values *Tmax* and *Tmin* can be changed also during measurement after pressing **F1**. The measurement is paused for short time, new temperatures are set up and the measurement continues. It should be emphasized that the maximum temperature cannot be selected lower than the actual temperature in the measurement process.

- The thermomagnetic curve is drawn automatically during the measurement. The computer selects itself the most convenient susceptibility scale, while the temperature scale is always the same, i.e. from 0 to 700 ^{o}C. In the case that one wishes to have another susceptibility scale, one can press **F1** and adjust the susceptibility scale manually.

- It should be emphasized here that the measured susceptibilities are the so called total susceptibilities (i.e. those not corrected for the specimen volume or mass). These susceptibilities are stored in the file and displayed on the screen. If one is interested in bulk susceptibilities, one has to enter the data of the specimen volume (or mass and density) or the bulk susceptibility of the measured specimen at the room temperature into the file. This can be made after measurement using the program CUREVAL (see AGICO Print No. 19), which enables the thermomagnetic curves to be presented in various ways (correction for empty furnace, smoothing, etc.)

- The way of determination of the Curie temperature from measured curve is illustrated on the following figure.



Data File Description

The data obtained by measurement are stored in random access ASCII files made automatically during measurement. Each file contains the data of one specimen and has the extension **.CUR** for high temperature data and **.CLW** for low temperature data.

- The first record contains the abbreviations of the parameters stored in individual columns.
- The second and other records contain the values of the measured and calculated parameters (later by program Cureval) specified in the following table.

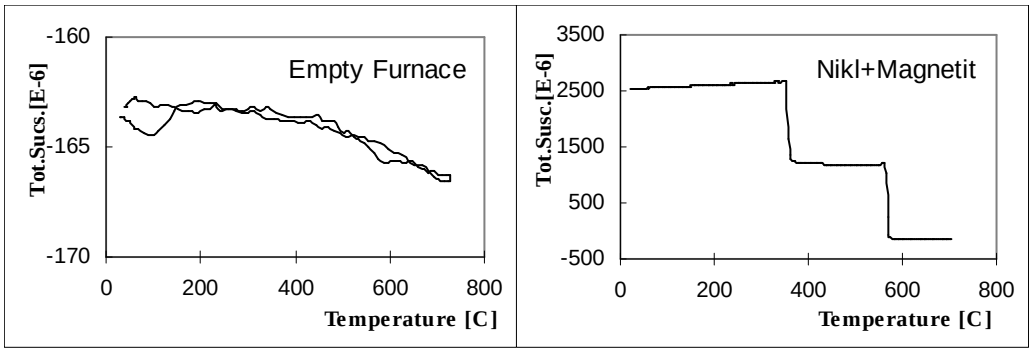
Abbreviation	*Length*	*Parameter stored*
TEMP	9 bytes	temperature (in degrees centigrade)
TSUSC	9	uncorrected total susceptibility
CSUSC	10	total susc. corrected for empty furnace
NSUSC	6	susceptibility normalized by maximum value
BULKS	12	bulk susceptibility
FERRT	9	total susc. of separated ferromagnetic comp.
FERRB	9	bulk susc. of separated ferromagnetic comp.
TIME	7	time of measurement (in seconds)
(AUXI)	9	auxiliary data

- The column containing the auxiliary data is not headed *AUXI,* but by the name of the free furnace for which the measured data are corrected (F20056 in our example shown below). The suceptibilities except the normalized ones are given in the order of 10^{-6} [SI]. The file appears as in the following example :

TEMP	TSUSC	CSUSC	NSUSC	BULKS	FERRT	FERRB	TIME	F20056
21.2	-164.4	12.94	.650	815.0	2.3	147.2	0	815
21.5	-164.4	12.74	.640	802.4	2.1	135.3	16	.170

for details see Manual Cureval (Agico Print No. 33)

- Here are examples of High Temperature Measurement with CS-3.



Measuring Temperature Variation of Magnetic Susceptibility Using Program SUFTEL

The operation of the program SUFTEL is very similar to SUFTE program, only some parameters which have no sense in low temperature measurement are omitted.

Purpose

The program SUFTEL serves for on-line measurement of temperature variation of magnetic susceptibility of rocks, by means of the CS-3 and CS-L Apparatus and Kappabridge KLY-4S, in temperature range from -192 ^{o}C to ambient temperature.

This program requires DOS ver.4.0 and higher, and VGA graphic card.

Running the Program

- Put the high temperature furnace to its standby position without connecting it. If you used in the last session SUFAM prog. remove the plastic cylinder from coil.
- Install the cryostat to the holder and connect the 9-pin connector located on the upper part of the pick-up unit.

- Check if the cryostat is properly mounted in the notch, if the tube for output the liquid nitrogen is not damaged. Check also if the temperature sensor is connected.

- If you do not temporarily use the CS-3 furnace and/or the cooling system is from some reasons open, unplug the Pump from rear panel of CS-3 Unit before switching the system on.
- Switch on the KLY-4S / CS-3 / CS-L system .
- After switching the KLY-4S on, the CS-3 and the pump (if plugged) are switched on for a few seconds (for testing the interconnection between the instruments) and then switched off. The CS-3 is switched on again and the pump is switched off by software commands later during the initialization of the CS-3 unit.
- Run program SUFTEL.EXE.
- After the program is started, the communication of the instrument with the computer via the serial channel RS-232 is tested.
- If communication failed check configuration file SUFTEL.SAV. See also the chapter, Testing the communication with computer, in this Manual Part 1.

- If everything is O.K., prepare the specimen and insert the measuring tube with the thermometer into the cryostat.
- The calibration procedure is available only if the temperature in the cryostat is higher than 0 ^{o}C. If you wish to calibrate the instrument, perform it at the beginning of daily session.
- Follow the instruction on the computer screen.

- Fill liquid nitrogen very slowly and wait for required temperature.

- Do not fill more nitrogen than is the level where the Teflon white body is decreasing its diameter.
- After the minimum temperature is reached the computer beeps - it is the attention to be ready to apply argon gas to force out the nitrogen out of the cryostat.
- Wait for the message 'Apply Argon and Start Measurement' - then use argon gas, flow about 20 l/min for approx. 3 sec., wait a few seconds and apply argon one again, two or three times. When the argon is flowing into the cryostat, press the front hole by finger at the same time to increase the pressure of the argon inside the cryostat to achieve easier deplenishing of the cryostat.
- If there is no liquid nitrogen inside the cryostat start measurement by pressing START Key F5.
- During measurement you can change the value Tmax. and the scale for susceptibility axis (in SI unit).
- Here are examples of Low Temperature Measurement with CS-L.